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A DESCRIPTION OF THE INTERNAL PLANNING PROCESSES OF THE MAJOR U--ETC(U)

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NAVAL POSTGRADUATE SCHOOL

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A DESCRIPTION OF THE INTERNAL PLANNING PROCESSES

OF THE MAJOR U. S. MILITARY AIRFRAME BUILDERS

by

John D. Finnerty

The Systems Acquisition Research Program

February 1977

Approved for public release; distribution unlimited.

NAVAL POSTGRADUATE SCHOOL
Monterey, California

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This paper describes the long term and short term planning processes of the nine major military airframe builders in the United States. The first part of the paper characterizes the nine firms and explores the risks and rewards inherent in their dependence on their major customer, the United States Government. The remainder of the paper provides a description of the internal planning processes that is based on personal interviews of the planning executives of the nine firms. The environmental forecast, which precedes the formulation of the long term and short term plans, and the corporate

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ABSTRACT

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TABLE OF CONTENTS

TABLE OF CONTENTS CONT.

LIST OF TABLES

LIST OF FIGURES

A DESCRIPTION OF THE INTERNAL PLANNING PROCESSES OF THE MAJOR U.S. MILITARY AIRFRAME BUILDERS [1]

A. INTRODUCTION

Over the last five years many articles have appeared in the business literature describing the problems that in recent years have plagued the United States aerospace industry, and in particular, the major military airframe builders [2] - the nine firms listed in Table 1 that serve as prime contractors for the production of the tactical, bomber, and support aircraft used by the Air Force, the Marine Corps, and the Navy to carry out their respective missions. There have been reports of an impending shake-out of makers of tactical planes, due mainly to the apparent reduction in the number of contracts for new military tactical aircraft. [3] A prolonged slump in defense spending for weapons systems procurement that began in 1970 and the political debate over the future of the Bl bomber program that delayed - and still threatens to put an end to - its production placed added pressure on the stability of the industry. [4] In addition, commercial aircraft sales fell dramatically as airline passenger traffic leveled off, [5] precipitating a financial crisis for one of the three major producers of both commercial and military aircraft. [6]

More recently, the 1976 national elections and the well-publicized upturn in real defense spending that began the same year have drawn the attention of not only the business community, but also the public,

Table 1: Profile of the Nine Major Airframe Builders by Major Military Program

Company	Military Aircraft in Production[1]	
Boeing	E-3	(airborne command and control)[2]
	Advanced Airborne Command Post[3]	
Fairchild	A-10	(attack)
General Dynamics	F-16	(fighter)
Grumman	E-2	(radar)
	A-6	(attack) / EA-6 (radar)
	F-14	(fighter)
Vought (LTV)	A-7	(attack)
Lockheed	C-130	(transport)
	S-3	(antisubmarine)
	P-3	(antisubmarine)
McDonnell Douglas	F-4	(fighter)[4]
	F-15	(fighter)
	A-4	(attack)[5]
	F-18	(fighter)[6]
Northrop	F-5	(fighter-trainer)[5]
	F-18	(fighter)[6]
Rockwell	B-1	(bomber)

1. Or soon to go into production.

2. Uses the Boeing 707 airframe.

3. Uses the Boeing 747 airframe.

4. Total deliveries of approximately 5000 aircraft.

5. Total deliveries of approximately 3000 aircraft.

6. The F-18 will be produced jointly by McDonnell Douglas and Northrop.

Sources: Company Form 10-K reports for company fiscal year 1975 submitted to the Securities and Exchange Commission.

to the defense industry - those firms that produce the weapons systems on which the nation's defense depends. More importantly, the turnabout in defense spending has brightened the general outlook for the aerospace industry considerably.[7] New arms programs, such as the F-16 to be produced by General Dynamics and the F-18 to be produced jointly by McDonnell Douglas and Northrop, have meant that, for some aerospace firms at least, the future looks very bright. For others, however, the trend toward longer production runs and fewer contracts threatens their continued existence as prime contractors. Indeed, in the absence of a sufficient number of new programs, a shakeout will occur and the victims will be forced to increase foreign sales or to work as subcontractors, or else to drop out of the aircraft end of the aerospace business altogether.

The next section describes these and several other problems that confront the major airframe builders, and in particular, how the uncertainties concerning the future state of product market demand, future resource availabilities and costs, etc., that all firms face are compounded by the technological uncertainties that result from having to push the state of the art each time a new weapons system is developed, and in addition, by a dwindling number of contracts from its principal customer - the Department of Defense - that threatens several firms' survival as prime contractors. In such a business environment, the need for effective corporate planning to somehow deal with these uncertainties is, in the opinion of this writer, critical. The development of a new weapons system normally requires several years or longer from conception to production. In addition,

the financial resources necessary to support the research and development effort are scarce - even though the Department of Defense does provide partial financial assistance through the distribution of independent research and development (hereafter referred to as IR&D) funds and in recent years has demonstrated a willingness to fund development programs on a cost-plus basis.[8] For these reasons it is necessary that these firms exercise particular care and forethought in allocating their scarce financial resources. Just as important, each of these firms must also allocate its highly skilled design and engineering talent among existing and proposed future projects. In each case the problem confronting the firm's managers is one of deciding how best to allocate the firm's resources to meet their own objectives and the objectives of the firm's shareholders.[9]

The purpose of this paper is to provide a description of the long term and short term planning processes of the nine major military airframe builders in the United States. The focal point for the discussion is how these planning processes are designed to ensure an allocation of the firm's fixed and variable resources that is consistent with the firm's goals and objectives. Section C sets out the general objectives the major airframe builders seek to accomplish when they plan their long term strategies and annual operations. Sections D through F discuss in broad terms the internal planning processes of these firms.

The description represents a synthesis of these firms' planning procedures, rather than an attempt to describe with perfect accuracy how any one firm plans. Though there are certain differences in how these firms plan, these differences are, in the opinion of this writer, differences of detail rather than of substance, and there is sufficient commonality in the ways these firms plan to justify the synthesis attempted here. Section G, which describes the corporate review process that follows the planning processes and Section H, which presents the summary and conclusions complete the paper.

Before proceeding to the discussion of planning, it may prove helpful to the reader to provide an overview of the major military airframe builders: their distinguishing characteristics, the peculiar problems they face, and their rather special relationship with their main customer, the Department of Defense (hereafter DOD). This is the purpose of the next section.

B. AN OVERVIEW OF THE NINE MAJOR MILITARY AIRFRAME BUILDERS IN THE UNITED STATES

1. Introduction

The United States aerospace industry is composed of approximately 50 major manufacturing firms [10] together with hundreds of other smaller firms that produce parts and auxiliary equipment. [11] The industry is a large contributor to the nation's output and employment. During 1975 aerospace sales made a direct contribution to gross national product of 1.9 percent, and accounted for 2.6

percent of all manufacturing sales and 5.4 percent of durable goods production.[12] Aerospace employment during 1975 averaged 942,000 workers, or approximately 1.5 percent of total civilian employment and 5.1 percent of total employment in manufacturing.[13] Also during 1975, U.S. aerospace firms rung up a record trade surplus of $7 billion, or approximately 75 percent of the total U.S. trade surplus.[14]

The output of the aerospace industry consists chiefly of aircraft, missiles, space systems, parts, and auxiliary equipment. Of these products, civil and military aircraft account for nearly 55 percent of the industry's output.[15] Of all the firms in the aerospace industry, there are nine - Boeing, Fairchild, General Dynamics, Grumman, LTV,[16] Lockheed, McDonnell Douglas, Northrop, and Rockwell - that serve as the prime contractors for all of the major tactical, bomber, and support aircraft used by the military. In addition, three of the nine - Boeing, Lockheed, and McDonnell Douglas - are the principal producers of large commercial aircraft in the United States.[17]

Turning to the buying side, during 1975 the federal government purchased nearly 60 percent of the aerospace industry's output, and over the last decade, the federal government's share of the industry's output has reached as much as 74 percent.[18] This dependence on government sales makes aerospace production susceptible to large swings in the level of government demand, as national policy and economic conditions change[19] and as the nation experiences alternating periods of war and peace.[20] In addition, the business cycle, as it affects

national disposable income and the demand for commercial airline travel, causes fluctuations in the demand for commercial aircraft. When the two cycles coincide, as they have in recent years, output and employment within the aerospace industry can fall dramatically. [21]

The remainder of this section characterizes the nine major military airframe builders and explores the major risks associated with these firms' heavy dependence on a single customer.

2. Size and Diversification

The nine major military airframe builders are large multiproduct companies whose sales are, in general, heavily weighted toward aerospace products. There are, however, important differences in the extent to which these companies have diversified away from the aerospace business.

Table 2 provides a profile of the nine firms according to the 1975 sales of each and the value of new military contracts won by each during fiscal year 1975. Eight of the nine firms are among the 500 largest industrial corporations in the United States, as ranked according to annual sales by Fortune magazine. The ninth largest, Fairchild Industries, falls within the upper range of the second 500 largest. Six of the firms are among the 100 largest. What the table does not show is that several of the firms have experienced some slippage in their rankings since 1970 due to a shrinkage in orders for military and commercial aircraft. [22] Nevertheless, these firms remain large, [23] and one would expect that they face problems of organization and control similar to those faced by other large firms.

Table 2: Profile of the Nine Major Airframe Builders
By Sales and New Military Contract Awards

Company	1975 Sales $ Millions	1975 Rank Among the Fortune 1000 [1]	% of 1975 Industry Sales [2]	1975 New Military Contracts $ Millions [3]	1975 Rank Among DOD Contractors [4]
Boeing	3719	43	13.3	1561 (4.0)	2
Fairchild	219	607	0.8	192 (0.5)	34
General Dynamics	2160	98	7.7	1289 (3.3)	6
Grumman	1329	155	4.7	1343 (3.4)	5
Vought (LTV) [5]	525	37	1.9	366 (0.9)	17
Lockheed	3387	50	12.1	2080 (5.3)	1
McDonnell Douglas	3256	52	11.6	1398 (3.5)	4
Northrop	988	205	3.5	620 (1.6)	12
Rockwell	4943	31	17.7	732 (1.9)	10

1. Rankings were determined by Fortune magazine on the basis of each firm's total net sales for 1975.

2. Expressed as a percentage of total industry net sales to final customers, which were $28 billion and which were distributed among aircraft, missiles and space, and non-aerospace as follows: aircraft $15.2 billion; missiles and space $8.1 billion; and non-aerospace $4.7 billion; as reported in Harr, op.cit., p. 11.

3. The number in parentheses represents the value of 1975 new military contracts awarded as a percentage of $39.5 billion, the net value of all new military contracts awarded during fiscal year 1975.

4. Rankings determined by new contract awards during fiscal year 1975.

5. The 1975 sales figure is for the Vought Corp. subsidiary of LTV Corp. The Fortune 500 ranking is the parent company's ranking.

Sources: Fortune (May 1976); Fortune (June 1976); Harr, op.cit.; and Ridder and Heinz, op.cit., appendix J.

Table 2 also indicates where the nine firms fall in relation to the other firms that make up the list of the top 100 DOD contractors. Five of the top six DOD contractors are airframe builders, and the nine major airframe builders all fall within the top 34 DOD contractors.[24] The nine firms collectively accounted for almost 25 percent of new military contracts awarded during fiscal year 1975. It is apparent, then, that how well these firms plan and conduct their operations will be of considerable interest to DOD. Not only is DOD one of the biggest buyers of the products of each firm, but also, each firm is among DOD's largest suppliers of durable goods.

Table 3 shows how the sales of each of the nine companies are distributed among aircraft, missiles and space, and non-aerospace product lines. Four companies - Boeing, Fairchild, Grumman, and McDonnell Douglas - derive at least 80 percent of total revenue from the sale of aircraft, engines, parts, and auxiliary equipment, and these four companies, as well as Lockheed, each earn at least 90 percent of total revenue from the sale of these items and missiles and space equipment. For these five firms, non-aerospace production constitutes a relatively small part of the firm's total operations. In contrast, General Dynamics, LTV, Northrop, and Rockwell appear much less dependent on aerospace sales, with, for example, the sale of aerospace products amounting to only 12 percent of LTV's 1975 sales. However, even though the percentage contribution of aerospace sales may be relatively small, large variations in the level of such sales might still have a significant impact on the firm's profit and loss statement and on its balance sheet. At the opposite end of the

Table 3: Diversification of the Nine Major Airframe Builders
As Indicated by 1975 Product Line Net Sales
(Millions of Dollars and Percent)

Company	Aircraft [1]	Missiles and Space [2]	Total Aerospace [3]	Non-Aerospace	Consolidated Net Sales [4]
Boeing	3005. [5]	587. [5]	3592. [5]	127. [5]	3719. [5]
% Net Sales	81	16	97	3	100
Fairchild	189.6	16.4	206.0	12.5	218.5
% Net Sales	87	8	94 [6]	6	100
General Dynamics	342.0	326.7	668.7	1491.3	2160.0
% Net Sales	16	15	31	69	100
Grumman [7]	1140.7 [8]	113.4 [8]	1254.1 [8]	74.5	1328.6
% Net Sales	86	9	94 [6]	6	100
LTV	392.2 [9]	119.4 [9]	511.6	3787.2	4312.5
% Net Sales	9	3	12	88	100
Lockheed	2017. [5]	1263. [5]	3280. [5]	107. [5]	3387. [5]
% Net Sales	60	37	97	3	100
McDonnell Douglas	2636. [5]	433. [5]	3069. [5]	187. [5]	3256. [5]
% Net Sales	81	13	94	6	100
Northrop	537.3	0.	537.3	450.8	988.1
% Net Sales	54	0	54	46	100
Rockwell	523. [5]	832. [5]	1467. [5,10]	3476. [5]	4943. [5]
% Net Sales	11	17	30	70	100

1. SIC Code 372.

2. SIC Code 376.

3. Sum of columns 1 and 2.

Table 3 (continued)

4. Sum of columns 4 and 5.

5. Rounded to the nearest million.

6. Percentages may not sum correctly due to rounding errors.

7. Intergroup eliminations, which consist primarily of data processing services provided to affiliated companies (Grumman Form 10-K, p. 3), and income other than sales revenue (ibid., p. 7), have been eliminated in order to adjust the sales breakdown provided by Grumman Corp. (ibid., p. 1)- based on sales and other income - to a breakdown on the same basis - sales only - as the other figures provided in the table.

8. Estimates are based on Grumman Corp's published figure of 84% government sales, expressed as a percentage of sales and other income (ibid., p. 4), and the assumption that the government aircraft sales in 1975 were the same percentage of total government sales as in 1974 (90%, as reported in Ridder and Heinz, op.cit., Table 40, p. 205).

9. Very rough estimates which are based on an apportionment of government sales between aircraft and missiles on the basis of total dollar contract backlogs (as of December 31, 1975). See LTV Form 10-K, p. 10.

10. Includes $112 million listed in Rockwell's Form 10-K as "aerospace operations: other".

Sources: Company Form 10-K reports for company fiscal year 1975 and Ridder and Heinz, op.cit., p. 205.

spectrum, if a firm derives 80 percent or more of its revenue from the sale of aircraft and related parts and equipment, then the performance of the company is highly sensitive to variations in the demand for aircraft. For such firms, this greater dependence on sales of aircraft makes the need for a planning organization that can cope with the cyclical fluctuations inherent in the demand for commercial and military aircraft all the more pressing.

The picture of the major airframe builders that has emerged thus far is one of large firms that have diversified away from aerospace production to varying degrees, but that are still very much dependent for their overall success on the success of their aerospace operations. The next two subsections discuss the important characteristics of the aerospace research and development process and the aircraft production process and suggest several important implications for the internal planning processes of the major airframe builders.

3. Aerospace Research and the Aircraft Development Process

It is a characteristic of the aerospace industry that each new product pushes the state of the art. Whether the new product is a new military fighter aircraft capable of reaching greater speeds and carrying heavier payloads than its predecessors or a new commercial passenger jet that can achieve greater fuel economy while meeting more stringent noise standards, the development of the aircraft requires the expenditure of large sums of money for highly skilled scientific and engineering talent. Usually these expenditures must be spread over a long period of time before the aircraft is ready for

production. Often seven to 10 years - and sometimes even longer - will elapse between program initiation and completion.[25]

The long and expensive research and development process has important implications for the aerospace industry in general and for the major airframe builders in particular. First, the industry is labor-intensive, employing as many salaried workers as production workers.[26] In 1975 the U.S. aerospace industry employed nearly 20 percent of all U.S. scientists and engineers engaged in research and development, and at times this percentage has been as high as 30 percent. These scientists and engineers and the knowledge and experience they possess constitute a valuable capital resource, the efficient allocation of which is critical to each firm's overall performance.[27] It is of some concern to corporate planners, then, that major programs be time-phased in such a way that the firm's scientific and engineering talent can be kept fully employed in jobs requiring their skills.

A second implication of the special character of the research and development process in the aerospace industry is that large sums of money capital must be raised in order to finance the research and development process. For example, the production of a new commercial jet might require as much as $2 billion in research and development and initial production costs before the firm begins to recover its investment[28] - a sum that far exceeds the net worth of any of the commercial airframe builders.[29] The financial pressures these firms face are, however, mitigated to a great extent by

government funding of IR&D, by development contracts that are typically awarded on a cost-plus-fee basis, [30] and, in the case of commercial aircraft development, by the spillover effects of research funded at least in part by IR&D money. Indeed, the aerospace industry is an anomaly among U.S. industries due to the extent to which the government - mainly through DOD and NASA, although the latter has diminished in importance rapidly in recent years as the total space effort has wound down - finances its research and development. [31] As an example of the importance of government funding, Lockheed Aircraft Corporation spent $52.8 million of its own funds on research and development during 1975, but received more than $480 million from DOD for defense-related research and development, testing, and evaluation. [32]

A third implication of the special nature of the aerospace industry's research and development process is the risks - technological, financial, and otherwise - inherent in expending large sums of money on new products that push the state of the art and that, in the case of new weapons systems, will lead to actual production only if the proposed weapons system (i.e. the prototype) survives a winner-take-all competition for the right to go into production. [33] As far as research and development per se is concerned, the main risk is that associated with technological uncertainty, namely, whether the firm will be able to make the required advances in the state of the art within a 'reasonable' period of time and at a 'reasonable' cost in accordance with its contract. [34]

A fourth implication of the special character of the industry's

research and development process is that the length of the process often makes it necessary for the firm's planners to look well beyond the five-year outlook provided by the Five Year Defense Plan in order to determine how to allocate defense-related research and development funds. While some guidance is provided by the projects on which DOD will permit IR&D funds to be spent, the airframe builders cannot rely on this source of information alone.[35] Moreover, for commercial markets there is nothing akin to a Five Year Defense Plan. Hence, planning the allocation of research and development funds necessitates projections of military and commercial needs in the next decade and beyond, and, needless to say, these projections involve a high degree of uncertainty. Coping with such uncertainty requires corporate planners to make certain adjustments in the way they plan, and these adjustments are discussed below in Section E.

This subsection has discussed the research and development requirements that underlie aircraft production and some of the important implications of the nature of this process and for each of the firm's planners. The next subsection takes a look inside these firms at the aircraft production process and at what the nature of this process implies for corporate planners.

4. The Aircraft Production Process and the Learning Curve

It has long been recognized by aeronautical engineers that airframe production is characterized by a learning process.[36] As the total number of airframes produced of a particular type increases, the direct labor input - the number of man-hours of labor per airframe -

diminishes.[37] This is due to the fact that, as the airframe is put together, items such as hydraulic systems, fuel lines, electrical wiring, and avionics gear must be installed by hand. As the total number of airframes increases, the production workers who install these items become more proficient - the experience gained on previous airframes has taught them what goes where, so that aircraft drawings need not be consulted as often as on earlier airframes, and has also taught them the best order in which to install the various items.

Studies of airframe production have revealed the shape of the learning curve.[38] The typical learning curve is what is called an '80 percent curve', which means that every time airframe production is doubled, the direct labor input per airframe declines by 20 percent, or equivalently, falls to 80 percent of what it was before production doubled. Such a curve is shown below in Figure 1, where it has been assumed that the first airframe requires a direct labor input of 8,000 man-hours.[39]

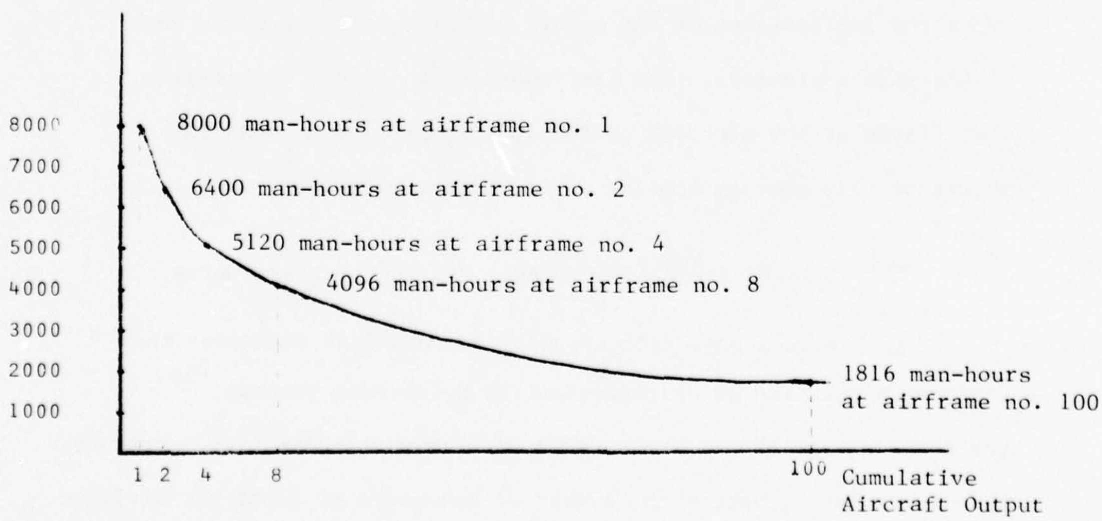

Figure 1: 80 Percent Learning Curve

It should be emphasized that the learning curve, and the process of learning by doing that it embodies, applies to all airframes singly. Each completely new airframe requires that the learning process begin anew. This is one reason why corporate planning within the major airframe builders proceeds on a more or less airframe-by-airframe basis. This point is developed further in later sections.

The existence of the learning curve has several important implications for corporate planners in addition to the one just mentioned. First, the fall in the direct labor input per airframe means that, barring major design changes that seriously disrupt the learning process or a surge in inflation that sharply increases the cost of labor and other inputs, both the marginal fly-away cost and the average fly-away cost of a particular type of aircraft tend to fall as the cumulative number of units produced increases.[40] This would imply that, from a cost standpoint at least, it is more economical to have a smaller variety of aircraft in order to derive maximum benefit from the learning curve. Thus, it might be argued that producing a common lightweight fighter aircraft that meets the needs of both the Navy and the Air Force, rather than producing a different airplane for each, would enable the government to take maximum advantage of the learning curve. It should be emphasized that such commonality can prove to be more cost-effective (rather than simply less costly) only if a compromise design that will effectively satisfy each service's needs proves feasible.[41]

Second, the existence of a learning curve makes it impractical for the Department of Defense either to have more than one firm

build a particular type of aircraft or to switch contractors once production has begun. In the first case, the full benefits of the learning curve could not be derived (i.e. for any given budget, fewer aircraft would be produced), and in the second case, the new contractor would have to begin at the top of the learning curve and a portion of the overall cost savings that had previously been possible would have to be sacrificed. Thus, by the time an airframe builder has won the initial production contract, there is no longer any effective competition on the selling side of the market, [42] and the government-contractor relationship becomes one of bilateral monopoly. [43] The significance of this is explored further below.

Third, the learning curve gives rise to a special problem for the producers of commercial aircraft, which are typically fixed-priced. Before fixing the price and announcing the price to the commercial airlines, the producer must make a careful assessment of the likely future demand for his product, for the lower is the price, the greater is the number of planes that must be sold before the break-even point is reached. An overly optimistic demand projection - say, one that overestimates either the need for additional carrying capacity or the need for replacement aircraft (or both) - can lead the producer to charge a price that implies an unattainably high break-even point, and, as Lockheed's L-1011 experience demonstrates, to intolerably large losses should the expected sales fail to materialize. [44] While the risk of such losses would tend to discourage the firm from setting the break-even point too high, the existence of strong competition among sellers of

commercial aircraft, as well as each producer's desire to sell sufficient numbers of aircraft to keep its production lines in continuous operation, push prices in the opposite direction by tending to make producers overly optimistic with regard to how fast they can proceed down the learning curve.

A fourth implication of the existence of the learning curve concerns the relationship between the production of commercial aircraft and the production of military aircraft. If a producer of both commercial and military aircraft can win a contract to produce a military plane that utilizes the same airframe as one of the company's commercial planes,[45] then that company will gain an advantage over its commercial competitors to the extent that it is able to progress down the learning curve more quickly than it could have otherwise. Of course, the military buyer also benefits by saving, not only on research and development costs, but also on a portion of what it would otherwise have cost to produce the military airframes. This is yet one more important aspect of the interface between government sales and commercial sales.

This and preceding subsections have menioned the importance of government sales to the major airframe builders. The next two subsections look more closely at the importance of government sales and at the risks involved in doing work under contract for the government.

5. The Importance of Government Sales

During 1975 almost 60 percent of the aerospace industry's total output was purchased by the federal government.[46] For the

nine major airframe builders the proportion of total net sales made to the government was somewhat less, amounting to nearly 55 percent of the total. [47] This high proportion of government sales means that these firms' total sales, and indirectly their profits and overall financial health, are very sensitive to changes in the amount of DOD weapons purchases. A somewhat more informative picture of this dependence emerges when total sales figures are broken down between government sales and commercial sales on a company-by-company basis. This is done below in Table 4.

Including sales of aircraft and other items to foreign governments among 'commercial sales' - in accordance with an accounting convention adopted throughout the industry - yields the percentages of government sales in consolidated net sales shown in column six. [48] These percentages range from a low of 38 percent in the case of Boeing and Rockwell to a high of 88 percent in the case of Vought Corp., with seven of the nine firms deriving more than half their revenue from government sales. The main reason Boeing has such a low percentage of government sales is its relatively high proportion - 60 percent - of sales of commercial aircraft. At the opposite end of the aircraft sales spectrum, Grumman Corp. derived 77 percent of its total revenue from sales of aircraft to the government.

The dependence of these firm's total sales on government sales, in general, and on sales of aircraft to the government, in particular, means that changes in the DOD budget can have a significant impact on the sales and levels of employment of these firms. [49] It is not surprising,then, that, as part of the corporate planning

Table 4: Proportion of the Nine Major Airframe Builders' 1975 Net Sales Made to the Government (Millions of Dollars and Percent)

Company	Aircraft [1] Comm	Aircraft [1] Gov't	Non-Aircraft [2] Comm	Non-Aircraft [2] Gov't	Total Comm [3]	Total Gov't [4]	Consolidated Net Sales [5]
Boeing [6]	2238.	767.	68.	646.	2306.	1413.	3719.
% Net Sales	60	21	2	17	62	38	100
Fairchild	78.2	111.4	16.4	12.5	94.6	123.9	218.5
% Net Sales	36	51	8	6	43 [7]	57	100
General Dynamics	77.6	264.4	757.4	1063.6 [8]	832. [6]	1328. [6]	2160.0
% Net Sales	4	12	35	49	39	61	100
Grumman [9]	119.6	1021.1	74.5	113.4	194.1	1134.5	1328.6
% Net Sales	9	77	6	9	15	85 [7]	100
Vought (LTV)	49.3 [10]	342.9 [10]	13.7 [10]	119.4 [10]	63.0	462.3	525.3
% Net Sales	9	65	3	23	12	88	100
Lockheed [6]	559.	1458.	626.	744.	1185.	2202.	3387.
% Net Sales	17	43	18	22	35	65	100
McDonnell Douglas [6]	1277.	1398.	148.	433.	1425.	1831.	3256.
% Net Sales	39	43	5	13	44	56	100
Northrop	220.9	316.4	154.7 [11]	296.1	375.6	612.5	988.1
% Net Sales	22	32	16	30	38	62	100
Rockwell [6]	196. [12]	327.	2869. [12]	1551. [13]	3065.	1878.	4943.
% Net Sales	4	7	58	31	62	38	100

1. SIC Code 372.

2. Mainly missiles and space (SIC Code 376).

3. Sums of columns 1 and 3. Commercial sales include sales to foreign governments, in accordance with the accounting practices of the industry. Entries may not sum correctly due to rounding errors.

Table 4 (continued)

4. Sum of columns 2 and 4. Government sales include sales to the U.S. government only. Entries may not sum correctly due to rounding errors

5. Sum of columns 5 and 6.

6. Sales figures are rounded to the nearest million.

7. Percentages may not sum correctly due to rounding errors.

8. Includes sales of $305.7 billion earned on new submarine construction.

9. See footnotes 7 and 8 of Table 3.

10. Very rough estimates based on an apportionment of sales given in columns 5 and 6 on the basis of total dollar contract backlogs (as of December 31, 1975). See <u>LTV Form 10-K</u>, <u>op.cit.</u>, p. 10.

11. 'Construction' plus 'Other'. See <u>Northrop Form 10-K</u>, <u>op.cit.</u>, p. 1.

12. Commercial sales are divided between aircraft and non-aircraft by assuming that the percentage split was the same in 1975 as it was in 1974 (6.4% aircraft - 93.6% non-aircraft; Ridder and Heinz, <u>op.cit.</u>, Table 40, p. 205).

13. Primarily 'missiles and space' and 'electronics'.

Sources: Company Form 10-K reports for company fiscal year 1975 and Ridder and Heinz, <u>op.cit.</u>, Table 40.

process, these firms carefully prepare environmental forecasts that provide the planning staff with an assessment of the likely political and military environment and what defense policy and military hardware needs are likely to be in such an environment, as far as five to 10 years into the future.

An aerospace company's dependence on government sales, particularly if a large percentage of its sales are derived from a single contract, may subject the firm to a significant termination risk, since the government may terminate a contract for its convenience at any time.[50] This risk and the other risks involved in doing business with the government are discussed in the next subsection.

6. Doing Business with the Government: Risks and Regulations

The recently completed Department of Defense Profit Policy Study (nicknamed Profit '76), which entailed an analysis of defense industry risks and profitability and which led to important revisions in DOD procurement policy,[51] once again raised the question of whether the profits contractors earn on government work are commensurate with the risks they must bear in performing such work. As the Profit '76 study and several earlier studies have noted, working under contract for the government involves certain risks not present in commercial dealings, and the scale of these risks is dependent on the type of contract awarded.[52]

It is not the purpose of this subsection to attempt to determine whether defense work is of a relatively high risk/low return nature. That issue has been debated - often heatedly - many times in the past,[53] and in the opinion of this writer, the debate is likely to

continue well into the future as DOD procurement policy changes and as each side reassesses the relative risks and rewards of government business.[54] One of the complicating factors in the debate is the nonquantifiability of risk. Many studies have listed the risk elements in government contracting,[55] but beyond that, it is very difficult to do more than adopt some surrogate measure - the Profit '76 study employed as a surrogate measure of risk the standard deviation of the firm's rate of return over a ten-year period.[56] Lack of agreement as to the most appropriate measure of risk will, to the extent that different measures lead to different conclusions, help keep the debate alive.

Whether government regulations permit profits sufficient to compensate defense contractors for the risks they face is also important from a planning standpoint. A firm will be willing to invest its own funds in new plant and equipment only if the expected returns from the investment, when adjusted for risk, are judged by top management to be adequate from the standpoint of the firm and its shareholders. If potential returns are felt to be inadequate, then top management will instead allocate the firm's available investment capital to commercial projects.[57]

The remainder of this subsection examines the buyer-seller relationship that exists between the federal government and its prime contractors - a relationship that is conditioned largely by the procurement policies that have been established by the government. The latter part of the subsection discusses how the government's procurement policies - and, in particular, the

type of contract it is willing to award - can affect the allocation of risk between buyer and seller. Unlike the studies of risk cited earlier, which either catalogued a long list of risks or else concentrated on developing a single overall measure of risk, this subsection develops a set of risk classifications and clearly distinguishes (for any particular program) between those risk elements associated with the period prior to the award of the first production contract and those risk elements associated with the period following the award of the first production contract. In the opinion of this writer, such a distinction has important implications for corporate planners and top managers who must carefully weigh expected returns and risks before deciding how best to allocate the firm's scarce engineering, scientific, and managerial talent among current and proposed programs.

a. The Buyer-Seller Relationship

Government contracts are awarded and administered under a detailed set of rules spelled out in the Armed Services Procurement Regulation (ASPR), an imposing collection of volumes that totals more than 3000 pages.[58] The provisions of ASPR, together with thousands of additional directives and instructions, detail the conditions that must be met when the contract between buyer and seller, which specifies the obligations of both parties under the procurement agreement, is written. Such an agreement is necessitated by the fact that the procurement of weapons systems does not - indeed, can not - take place via normal commercial market transactions. In commercial markets firms design and develop new products entirely on their own and

finance research and development and initial production prior to observing the actual demand for the good. Due to several factors, among them national security considerations, the high cost and long lead time required to develop new aircraft, and all the uncertainties connected with weapons system acquisition,[59] it is not in the best interests of the government to rely on this process for obtaining major weapons systems.[60] The government needs some assurance that it will get what it needs when it needs it and at a reasonable price, and the contractor needs some assurance that the government has a need for the new aircraft it is developing, as well as financial support during the lengthy and costly research and development process. Thus, there is the need for negotiation and contractual relationships to supplant the market place in determining product design, price, etc.

In discussing the buyer-seller relationship that exists between the government and the airframe builders, it is important to distinguish, for any particular program, between the period prior to the award of the initial production contract and the period following that award. The contracting process for a new type of aircraft begins with a Request for Proposals, which the government issues to interested bidders. These contain detailed specifications of the government's requirements. At this stage of the process, and continuing through the building of prototypes for a fly off, there are two or more sellers but only one buyer. The buyer-seller relationship is what economists call a 'monopsony' - two or more sellers competing against one another to sell their output

to the sole buyer.[61] In such an environment there is a danger that a contractor will submit an unrealistically low bid or an unrealistically optimistic set of technical specifications in order to increase its probability of winning.[62] This danger increases when there are not enough major contracts to go around, and increases even further when the procuring agency resorts to auctioning - i.e. asking contractors whose bids fall within the competitive range for "best and final" offers.[63] During this portion of the contracting process the main risks the contractor faces are those associated with either losing the competition or else winning the competition but finding it impossible to meet the terms of the contract.[64]

Once the aircraft has gone into production, however, the buyer-seller relationship changes dramatically.[65] The existence of the learning curve precludes further competition among airframe builders, and the government-contractor relationship becomes one of 'monopsony' - a single buyer and a single seller. Production contracts are typically renegotiated on a yearly basis. But once the plane has gone into production, there no longer remain any technical uncertainties. Moreover, the shape of the learning curve is known well enough that labor costs can be estimated fairly accurately, at least over the next year.[66] Though the cost of components purchased from subcontractors can change, the degree of risk associated with cost increases that diminish net income is relatively small. However, there is always a risk that the government will terminate the contract at its convenience, reimbursing the contractor for costs incurred up to the termination

date and paying it a pro rata share of the previously negotiated fee, but leaving it on its own to decide what to do with facilities and a labor force for which there is no longer any need. The importance of the termination risk is difficult to assess, but, in the opinion of this writer, is likely to be small in relation to the risks associated with not winning the contract in the first place.

After the contractor has performed the work required under the contract and been paid, any profits it may have earned are subject to scrutiny by the Renegotiation Board. [67] The board averages contractor performance on all contracts on a yearly basis, and if it determines that during the year under review the contractor earned 'excessive' profits, it recaptures the 'excess' for the government. This review process is, however, a one-way street because the contractor has no recourse in the event it believes its profits were too low that year. [68] Moreover, the determination of the reasonableness of each contractor's profits is made on the basis of a set of six criteria [69] that are widely regarded as vague and subjective. [70] Government contractors and independent analysts have criticized the Renegotiation Board's decisions as arbitrary. [71] Kaysen and others believe that the way the government does business, and in particular, the operation of the Renegotiation Board, dulls whatever incentives exist in individual contracts for promoting efficient contractor performance. [72]

This subsection has mentioned several of the risks involved in government contracting. The next subsection examines these and other associated risks.

b. Financial Risks and Business Risks

The term 'risk' is one that is subject to varying interpretations. Some authors treat 'uncertainty' as a synonym for 'risk', [73] while others follow Knight [74] and distinguish 'uncertainty', which is held to be 'elusive and nonmeasurable', from 'risk' which is held to be measurable. [75] Financial and business writers often use the term 'risk' in an all-inclusive manner to encompass all the assorted uncertainties, most of which are not susceptible to measurement, that confront a firm, while financial management textbooks normally aim for a higher degree of precision, often carefully distinguishing between 'business risk', measured, say, as the coefficient of variation of the firm's net operating income, and 'financial risk', measured, say, as the coefficient of variation of the firm's net income (or earnings available to shareholders) or as the probability of bankruptcy. [76] Studies dealing with the specific subject of risk elements in government contracting tend to drift to either of two extremes: either providing a long list of sources of uncertainty [77] or else selecting some single overall measure of risk. [78] One exception is a recent publication of the Aerospace Industries Association of America [79] that categorizes risks that confront aerospace firms into four broad classes. A similar approach is adopted in the first portion of this subsection, although the categories differ somewhat and, in contrast to the earlier approach, a surrogate measure of each of the risks in each category is suggested.

The major types of risk that are encountered by the nine major military airframe builders are discussed below. Many of these risks,

as indicated below, are those that affect all government contractors. In what follows a distinction is drawn between *financial risks* and *business risks*, but as the discussion makes clear, government contracting affects both types of risk.

As discussed above, financial risk, which must be borne to some extent by all corporations, encompasses the risk of bankruptcy and the variability in the firm's net income. Surrogate measures for these two components of financial risk are the probability of bankruptcy and the coefficient of variation of net income, respectively.[80] The probability of bankruptcy is, of course, the ultimate risk that any business organization faces, but, in the case of the major airframe builders, this risk is, according to at least one expert, almost insignificant. Kurth has offered empirical evidence in support of his belief in a 'bail-out imperative' that prompts the government to come up with a new program and award it to a prime contractor in deep financial trouble.[81] Kurth would undoubtedly argue that the Navy's modification of the F-14 contract and the government's loan guarantee for Lockheed were merely different manifestations of the same phenomenon.[82] The second component of financial risk is also affected by the way the government does business. For example, Fairchild Industries, Inc., reported to its shareholders that "the transition from the development to the production contract [for the A-10 attack aircraft] substantially impacted 1975 sales and earnings."[83]

What distinguishes financial risks from business risks is that

only the former reflects the impact of the firm's financial decisions, and in particular, what proportion of the firm's capital has been raised through the issuance of debt instruments. Both financial risk, as defined above, and business risk, as defined below, reflect the impact of the operating decisions of the firm. In this sense, then, financial risk is the more inclusive term and can be thought of as the firm's overall risk.[84]

Business risks are of six types: (i) technical risks, (ii) bidding risks, (iii) production risks, (iv) cost risks, (v) government dependence risks, and (vi) commercial market risks. Each of these is discussed below.

Technical risks are those associated with pushing the state of the art each time a new military aircraft is developed.[85] Often there are several unknowns to be dealt with, and even if the firm is confident it can solve each technical problem individually, there may remain much uncertainty concerning the time and cost required to accomplish these results and there may also be uncertainty as to how well the new integrated system incorporating all these advances will perform.[86] Since aerospace firms typically earn a greater portion of their sales revenue on research and development work than do firms in other industries,[87] this source of uncertainty is of somewhat greater significance in the aerospace industry. However, in view of DOD's apparent increasing willingness to fund research and development on a cost-plus basis,[88] the impact of technical risks on the firm is correspondingly reduced. One way to measure these risks, while reflecting the importance

of government funding, is to estimate the firm's probability of failure to meet the contract's specifications. Since increasing the government's share of the costs makes it less costly for the firm to engage in an additional dollar's worth of research and development, as long as the additional dollar is spent productively, the probability of failure will tend to fall. Reducing this probability is in the firm's interest because failure to meet the contract specifications may result, not only in financial loss, but in loss of reputation as well.

The second category of business risk, bidding risk, is also associated primarily (although not exclusively) with government contracting. Prior to the award of a contract, the firms that intend to bid spend money, some of it their own and the rest of it the government's bid and proposal (B&P) money, preparing the bid. As in the case of technical risks, government funding helps reduce the impact of these risks. Also similar to technical risks, the measurement of bidding risk may be carried out by once again estimating the probability of failure, in this case, the probability of failing to win the contract.

The third class of business risk, production risk, is associated with fluctuations in the levels of demand for the firm's product that lead to volatility in manpower requirements. One major source of fluctuation in demand for military aircraft is the rapid buildup and the rapid phasing out that accompany the start and completion, respectively, of a major government contract.[89] Such fluctuations may force the firm through successive periods of

layoffs and rehirings, both of which involve substantial direct and indirect costs. For example, where labor unions exist, one would expect on the basis of economic theory [90] that unions would press for higher wages in order to obtain for their workers a risk premium to compensate them for the risk of being laid off. A more serious problem from the company's standpoint is the threat of not being able to rehire previously laid off skilled scientific or engineering talent or skilled line managers because they were hired by other firms, or worse yet, because they left the industry. Any measure of the volatility of aerospace employment, such as the coefficient of variation of the number of employee-hours per week over some specified time period, might serve as a measure of this type of risk.

The fourth category of business risk, cost risk, involves the contractor's possible failure to produce the item within target cost. This category of risk overlaps with technical risk, since the greater is the technical complexity of the item - i.e. the greater are the technical risks - the greater is the risk that actual costs will exceed target cost. As discussed below, when research and development contracts are of the cost-plus form, the government assumes most of the cost risk. On production contracts, on which the technical risks are normally much smaller than on research and development contracts, but on which the government normally insists on a fixed price, there is also cost risk. This risk is induced by such factors as production delays, design changes ordered by the government that lead to cost increases that are not fully reimbursed, and increases in the cost of inputs due to general inflation that are

not fully covered in the contract. Also, as discussed below, the use of fixed-price contracts for the production phase of a major program forces a larger share of the cost risk to fall on the contractor.[91] As far as the measurement problem is concerned, cost risk on any contract or project could be measured either by the standard deviation of the probability distribution of actual cost about target cost - estimated, say, on the basis of historical data - or more simply, as the estimated probability that target cost will be exceeded.

Two other aspects of cost risk should be noted. First, to reduce bid risk the contractor may submit an unrealistically low bid, thereby increasing its cost risk. Second, the use of subcontractors can also have an impact on cost risk in two offsetting ways.[92] On the one hand, the greater use of subcontractors relaxes the prime contractor's direct control over those phases of research and development and/or production that have been contracted out, while on the other hand, a portion of the prime contractor's overall cost risk can be transferred to the subcontractor if the latter accepts the work on fixed-price basis.[93]

The fifth category of business risk, government dependence risk, also overlaps with the other categories of business risk. Government dependence risk is caused by a contractor's having to sell high technology military aircraft to (or at least through) a single buyer. This imposes certain risks in research and development work because the government must be satisfied with the product before it will authorize production, and in addition, because the contracting authority may alter its requirements as the weapons system evolves,

ordering the contractor to modify components, which in turn may have a ripple effect on other components in the system. A second aspect of government dependence risk is the volatility of government funding, which can have a strong impact on a contractor's production risk. The fall in DOD spending following the Vietnam war peak is one of the main factors responsible for the current overcapacity in the aerospace industry.[94] In addition, each of the above factors can also compound cost risk. A third aspect of government dependence risk is termination risk - the probability that the government may terminate a contract for convenience. Such termination may be due to a lack of funding, or to political pressures such as those threatening the B1 bomber program, or more simply, to altered priorities. In any case, the very limited possibilities for, and the very high cost in terms of direct outlays and loss of efficiency of, converting the production facilities to some alternative use[95] mean that layoffs follow, the contractor's business base and earnings shrink, and the amount of unused capacity increases. A fourth aspect of government dependence risk is that associated with the present very real possibility that, even if real defense spending continues to increase, the number of major contracts, and hence, the number of airframe builders needed to serve as prime contractors, may diminish.[96] As far as measurement of government dependence risk is concerned, one might adopt some measure of the volatility of a contractor's government sales, as, for example, the standard deviation of government sales (about a trend) over some specified period.

The last category of risks includes those risks that are strictly commercial, and as such, can be interpreted and measured in the

same manner as Van Horne's business risks. In the case of the three firms producing commercial passenger aircraft, however, it may be more meaningful to attach risks to specific programs. These are of essentially two types: the risk (i.e. the probability) of not reaching the break-even number of units sold for a particular type of aircraft and the risk (i.e. the probability) of a disastrous accident that will tarnish the company's image and might thereby detract from future sales. The first of these also reflects the risks associated with mistiming the introduction of a new commercial aircraft.[97]

One method of dealing with these substantial financial and business risks is for the airframe builders to cooperate through joint ventures.[98] This approach is superior from the standpoint of the firms involved to the more traditional prime contractor - subcontractor form of business relationship in that research and development are shared more equally and each producer shares in the production and marketing of the aircraft. Hence, in a joint venture each producer is a prime contractor,[99] and as will be argued below, it is prime contracting rather than subcontracting, and the prestige that accompanies the successful development and production of a new high technology aircraft that is one of the primary sources of satisfaction for the managers of these firms.[100]

c. The Government - Airframe Contractor Relations: Allocation of Risks by Contract Type

Having indicated the major sources of risk, the discussion will deal next with the question of risk-sharing between the government and the contractor. At one extreme, the government could provide all the fixed capital (i.e. plant and equipment) and all the working

capital (i.e. short term funding for inventories and work in process) and pay the airframe contractor a fixed fee for managing these assets. In this case the government would assume the larger share of business risk. At the opposite extreme, the contractor could provide all its own fixed and working capital and accordingly assume all the business risk. In reality, the government does furnish some fixed capital,[101] although it appears to be trying to phase out its plant ownership role in the aerospace industry.[102] The government also funds a large portion of the major airframe builders' working capital requirements by providing progress payments,[103] though with interest now an allowable cost, the extent of government funding of working capital requirements may decrease.[104]

One of the most important mechanisms by which the government is able to shift risk between itself and the airframe builder is by its selection of the type of contract for a particular procurement.[105] Several studies have examined the relationship between contract type, the extent of the risks borne by the contractor, and contractor performance.[106] Procurement contracts are of four basic types: firm-fixed-price (FFP), fixed-price-incentive (FPI), cost-plus-incentive-fee (CPIF), and cost-plus-fixed-fee (CPFF).[107] As implied by the fee ranges set by the Department of Defense,[108] the government's share of overall risk (and, in particular, its share of cost risk) is greatest under CPFF contracts, somewhat less under CPIF contracts, less yet under FPI contracts, and least under FFP contracts. Correspondingly, the contractor's share of the risk and its fee become greater as the government's share of the risk falls.[109]

A third mechanism by which risk is shifted is via government contract provisions regarding warranties.[110] The purpose of a warranty is to protect the buyer in the event the item turns out to be defective. The warranty typically specifies the extent of the producer's liability for repairing or replacing defective items. Several comparisons of government contract provisions regarding warranties with commercial warranties have shown government warranties, in general, to be more demanding.[111] The existence of more stringent warranties has the effect of increasing the share of technical risk, and hence the share of overall financial risk, borne by the firm, since ceteris paribus the more exacting are the standards, the greater is the likelihood they cannot be met, and consequently, the greater is the likelihood the contractor will suffer some sort of financial penalty.

This subsection has examined the government-airframe contractor relationship and has discussed the major risks airframe contractors face and how government procurement policy affects the sharing of these risks with its prime contractors. The next subsection looks at the commercial side of the airframe builders' business, and in particular, at their attempts to diversify in order to reduce their dependence on government sales.

7. Diversification: Balancing Government Business and Commercial Business

The previous subsection discussed some of the major differences between the buyer-seller relationship that exists between the government and a prime contractor and the buyer-seller relationship

that is typical of commercial markets. The subsection went on to point out the risks associated with this special relationship, and in particular, the risks a contractor faces as it becomes increasingly dependent on government sales. While commercial ventures also pose certain risks, some of which are of great magnitude, many of the major airframe builders have increased their efforts to diversify into non-aerospace commercial ventures in recent years.[112]

One reason offered to explain this desire to diversify is the relatively low profitability and the relatively high risks of government business. A second reason is the limited growth potential provided by government sales during recent years as real defense spending fell. Table 5 summarizes the recent profitability and growth experience of the nine major military airframe builders.

As the table shows, the median profitability, whether measured by the average return on equity or the average return on total capital, as well as the median net profit margin and the average annual sales growth, for the nine firms were below the respective median values both for the aerospace industry as a whole ('industry median') and for all industries taken collectively ('all industries median').[113] If one views a corporation as a business entity that exists primarily for the benefit of its shareholders, then, of the three indicators of profitability shown in Table 5, average return on equity is the most appropriate. Therefore, on the basis of this measure and the profitability figures provided,[114] one must conclude that whatever differences exist between the profitability of the major airframe builders and the profitability of other aerospace firms and firms

Table 5: Profile of the Nine Major Airframe Builders by Profitability and Growth (Percent and Percent Per Annum)

Company	Average Return on Equity [1,2]	Average Return on Total Capital [2,3]	Net Profit Margin [4]	Average Annual Sales Growth [5]
Boeing	6.8	5.8	2.3	1.5
Fairchild	6.2	5.0	1.9	-2.8
General Dynamics	13.3	10.5	4.0	-3.3
Grumman	9.3	3.5	2.1	2.3
LTV	12.3	5.8	0.6	6.5
Lockheed	46.8 [6]	5.9	1.2	4.8
McDonnell Douglas	12.6	9.9	3.2	2.3
Northrop	11.9	8.8	2.4	9.4
Rockwell	12.8	9.0	2.4	10.0
Median	12.3	5.9	2.3	2.3
Industry Median [7]	12.6	8.8	2.9	5.8
All Industries Median	12.7	9.1	4.6	11.8

1. Assumes that all "common stock equivalents" - convertible bonds, convertible preferred stocks, warrants, and stock options - have been converted into common shares.

2. Percentage computed as a five-year average of the returns computed for 1972 through 1975 and the 12-month period ending with the latest (as of December 1976) available quarterly report.

Table 5 (continued)

3. Percentage return on combination of stockholders' equity, long term debt, minority stockholders' equity in consolidated subsidiaries, and accumulated deferred taxes and investment tax credits. The numerator in the calculation is the sum of net income, minority interests in net income, and estimated after tax interest paid on long term debt.

4. Net profits for the latest (as of December 1976) 12 months divided by net sales for the same period.

5. Computed in the following manner: the difference between average annual net sales for the period 1972 through 1975 and the most recent 12-month period and average annual net sales for the period 1967 through 1971, expressed as a five-year annually compounded rate of growth. The averaging done in the calculation is intended to smooth out short run distortions.

6. Lockheed's very large avarage return on equity is an anomaly caused by that firm's very small equity (or net worth).

7. Industry median differs from the industry median listed in Forbes because Forbes did not include LTV among the aerospace firms.

Source: Forbes (January 1, 1977), pp. 39, 133, and 154.

in other industries are not significant.[115] It is equally clear from the figures provided in Table 5 that the major airframe builders have grown more slowly than other firms. Moreover, Rockwell International, which grew the fastest, was also the most active in acquiring other firms outside the aerospace industry.[116]

One direction in which the major military airframe builders might choose to diversify is the production of commercial jet aircraft. Indeed, three of the nine already dominate the world market.[117] The technological complementarity of military and commercial aircraft would tend to make such diversification appear attractive. Also, the character of the production processes is similar enough that managerial and productive expertise could also be transferred rather easily - certainly more easily than to, say, automobiles or food products. However, the demand for commercial aircraft is highly cyclical[118] and, despite the evident need for new jetliners,[119] the present outlook for commercial jet aircraft sales is clouded by the severe financial problems afflicting the nation's airlines[120] and the apparent peaking out of the growth of airline passenger traffic.[121] Moreover, the financial risks are enormous, with outlays for research and development and initial production amounting to as much as $2 billion before the producer begins to recover its investment.[122] The recent entry of foreign producers, supported by the vast financial resources of their governments, has greatly increased the competitive pressures faced by U.S. firms.[123] Thus, the opportunities for diversification in this direction are, in the opinion of this writer, virtually nonexistent.

Diversification into commercial non-aircraft product lines has also been carried out, and the major airframe builders have generally been more successful in those ventures than involve the transference of the technological expertise developed in their aerospace operations.[124] However, as Table 6 indicates, these commercial non-aircraft ventures have, in four cases, recently acted as a net drain on corporate net earnings.[125] Admittedly, some of these losses are due to the recent recession, rather than to the firm's basic inability to develop profitable commercial non-aircraft lines of business. However, the fact remains that the managerial skills required to oversee an organization that develops and produces a relatively small number of high technology products that it markets to only a small number of select customers are different from those required to mass produce and to market on a wide scale consumer-oriented goods and services. As a result, in trying to diversify into commercial non-aircraft ventures, the major military airframe builders have to be very careful where they invest their money,[126] and as the experience of Rockwell International would seem to indicate, diversification by external means (i.e. by taking over established firms) is preferable to diversification by internal means, since the former approach brings experienced managers into the firm and brings an established marketing network under its control.[127] More seriously, the limited opportunities for profitable diversification, when coupled with the relative inflexibility of the plant and equipment these firms operate, may have the effect of forcing these firms to accept (what they may regard as) subnormal profits without recourse to the avenue of relief open to firms in traditional economic theory - the ability to costlessly switch industries.[128]

Table 6: Proportion of the Nine Major Airframe Builders' 1975 Net Income Earned on Sales to the Government (Millions of Dollars and Percent)

Company	Aircraft[1] Comm	Aircraft[1] Gov't	Non-Aircraft[2] Comm	Non-Aircraft[2] Gov't	Total Comm[3]	Total Gov't[4]	Consolidated Net Income[5]
Boeing	55.1[6]		21.2[6]		-[6] [6]	-[6] [6]	76.3
% Net Earnings	72		28		-	-	100
Fairchild	5.7[6]		(2.7)[7]	0.2	-[6] [6]	-[6] [6]	3.2
% Net Earnings	145		NM[8]	7	-	-	100
General Dynamics	7.1	14.6	35.9	23.5	43.0	38.1	81.1
% Net Earnings	9	18	44	29	53	47	100
Grumman[9]	5.6	21.9[10]	(4.0)	-	1.6	21.9	23.5
% Net Earnings	24	93	NM	-	7	93	100
LTV[11]	26.1[6,12]		(32.5)	-	-[6] [6]	-[6] [6]	(6.4)
% Net Earnings	NM		NM	-	-	-	100
Lockheed	(52)[13]	84[13]	12[13]	1[13]	(40)[13]	85[13]	45[13]
% Net Earnings	NM	187	27	2	NM	189	100
McDonnell Douglas	-[6] [6]	-[6] [6]	-[6] [6]	-[6] [6]	-[6] [6]	-[6] [6]	85.6
% Net Earnings	-	-	-	-	-	-	100
Northrop	23.8[6]		(1.1)[14]	2.0	-[6] [6]	-[6] [6]	24.7
% Net Earnings	96		NM	8	-	-	100
Rockwell	7.3[6]		32.2	62.1	-[6] [6]	-[6] [6]	101.6
% Net Earnings	7		32	61	-	-	100

1. SIC Code 372.

2. Mainly missiles and space (SIC Code 376).

3. Sum of columns 1 and 3. Entries may not sum correctly due to rounding errors.

Table 6 (continued)

4. Sum of columns 2 and 4. Entries may not sum correctly due to rounding errors.

5. Sum of columns 5 and 6. Net income as listed in column 7 is figured net of interest and administrative expenses and net of federal income taxes, but before extraordinary items, for all companies except LTV. Due to a substantial tax-loss carryforward, LTV reported net income of $13.1 million for 1975 though without the carryforward the company would have shown a loss.

6. Breakdown between government and commercial cannot be determined from the company's Form 10-K.

7. Parentheses indicate a loss.

8. Not meaningful.

9. See footnotes 7 and 8 of Table 3.

10. Includes space.

11. Breakdown provided for LTV Corp. only because figures for Vought Corp. were not available.

12. Adjusted net income for Vought Corp., which includes net income earned from commercial aircraft business.

13. Rounded to the nearest million.

14. 'Construction' plus 'Other'.

Sources: Company Form 10-K reports for company fiscal year 1975.

In the course of interviews with executives of the major military airframe builders, the author was told that these firms would like to diversify into new product lines in order to reduce their dependence on the government.[129] These firms generally view government business as relatively risky and relatively less profitable than commercial business, and they see diversification as one way to reduce the overall risks they face.[130] Yet, as this subsection has tried to point out, diversification into commercial markets poses special problems for many of these firms. It is not surprising, then, that many of them have also pursued a different approach to risk reduction, namely, the expansion of foreign markets for their goods and the development of cooperative ventures with foreign producers. These developments are discussed in the next subsection.

8. Foreign Sales and Foreign Competition

As sales of military aircraft to the U.S. government fell following the Vietnam war and as domestic sales of commercial aircraft fell during the recent recession, one of the factors that helped sustain the U.S. aerospace industry was foreign sales of military aircraft. During 1975, for example, foreign sales of military aircraft and other aerospace products amounted to $2.5 billion[131] and accounted for 350,000 jobs and for seven percent of U.S. exports.[132] As domestic opportunities diminish, the major airframe builders have tried to expand foreign sales.[133] Such sales can, however, lead to political difficulties[134] since, even if the sales are made by the manufacturer directly to the

foreign government, they must be reviewed by various U.S. government agencies.[135] In addition, the foreign buyer may insist on certain conditions, such as the sharing of production with one or more firms in that country[136] or a guaranteed purchase by U.S. buyers of a certain amount of that country's exports,[137] as part of the deal.

In addition to the difficulties associated with having to make various concessions to foreign governments in order to sell airplanes, the U.S. airframe builders are meeting with increased competition from foreign builders of both commercial and military aircraft. Most of these foreign competitiors are supported financially by their governments.[138] Since many of the foreign commercial airlines are government-owned, the foreign government can direct its airline to buy domestically produced aircraft.[139] A third factor making for increased foreign competition is the multinational pooling of efforts, which permits the sharing of heavy development costs[140] and which can also serve to expand the 'guaranteed market' for a particular foreign aircraft.[141] These factors place the major U.S. airframe builders at a disadvantage, and in order to counter the risk of erosion of their foreign markets, several U.S. firms have recently entered into joint ventures with foreign aerospace firms.[142]

9. Summary

This section has provided an overview of the nine major military airframe builders in the United States. The discussion

has focused not only on the firms themselves, but also on the environment within which they operate, and in particular, on their relationship with their principal customer, the United States government, on the financial and business risks they must bear, and also on the increasing foreign pressures they face. With the material presented in this section as a background, the remainder of the paper describes how these firms conduct their long term and short term planning.

C. BACKGROUND TO THE PLANNING PROCESS: THE OBJECTIVES OF THE FIRM

1. The Planning Process

In light of the many risks associated with the aerospace business that were discussed in the previous section, as well as the apparent reduction in the number of major military aircraft programs and the intensifying foreign competition for both military and commercial aircraft sales, the following maxim culled from the office wall of an aerospace planning executive seems to this writer an appropriate way to begin this section:

"The company that doesn't plan for its future isn't likely to have one."

The overall purpose of the corporate and divisional planning conducted by the major airframe builders may be stated succinctly as follows: to allocate the company's scarce productive resources - manpower, facilities, and skilled managerial, engineering, and technical talent - and its scarce financial resources among existing and potential commercial product lines and among existing and

potential government contracts in accordance with goals and objectives of the company. The 'existing' in the above statement refers mainly to *short term*, or *operational*, *planning*, with its emphasis on the firm's most efficient use of its current stocks of capital resources - both physical capital in the form of plant and equipment and human capital in the form of the knowledge and skills embodied in the firm's managers, engineers, and scientists - and its emphasis on carrying out production to meet current commitments in the most efficient manner - in terms of minimizing production costs while maintaining product quality and contract performance (in an attempt to generate maximum sustainable earnings). The 'potential' in the above statement refers mainly to *long term*, or *strategic*, *planning*, with its emphasis on new business - and the most effective use of research and development funds, engineers, and scientists in order to develop the expertise necessary to develop new products and secure new government contracts - and its emphasis on the most efficient use of the firm's financial resources to purchase new production facilities and new equipment and to start up or acquire new businesses.

Planning, then, takes place on two levels: short term planning, for which the time period involved is typically one year, although some of the major airframe builders carry out operational planning over longer periods, and long term planning, for which the time period involved is typically five years, although some of the major airframe builders carry out strategic planning over longer periods.[143] As described below, consistency between the long term plan and the short term plan is achieved by first formulating the long term

plan and then using the first year of the long plan (or the first two years or five years if that is the firm's short term planning period) as the basis for the short term plan.

At both the strategic and the operational levels, planning is done iteratively. The nine major airframe builders are organized as multidivision companies, with one or more divisions producing aircraft and other aerospace products [144] and several divisions producing non-aerospace products, as illustrated in Figure 2. [145] Decision-making and much of the responsibility for planning are decentralized, although major decisions, such as those requiring capital investment, and strategic and operational plans must be cleared with the company's headquarters, which maintains its own planning staff - sometimes consisting of just one individual - and which ensures that the plans of the various divisions, when amalgamated, are consistent with the company's goals and objectives. Achieving this consistency may require several iterations between division and headquarters until the latter is satisfied with the former's plans.

The headquarters planning staff has an additional responsibility that is critical to the planning process. The corporate planning staff prepares annually an environmental forecast, which, as the name implies, characterizes the firm's operating environment over a period of years at least as long as the strategic planning period. Each division inputs information relating to its own area of expertise to the corporate planning staff, which gathers additional information relating to such areas as the general state of the economy

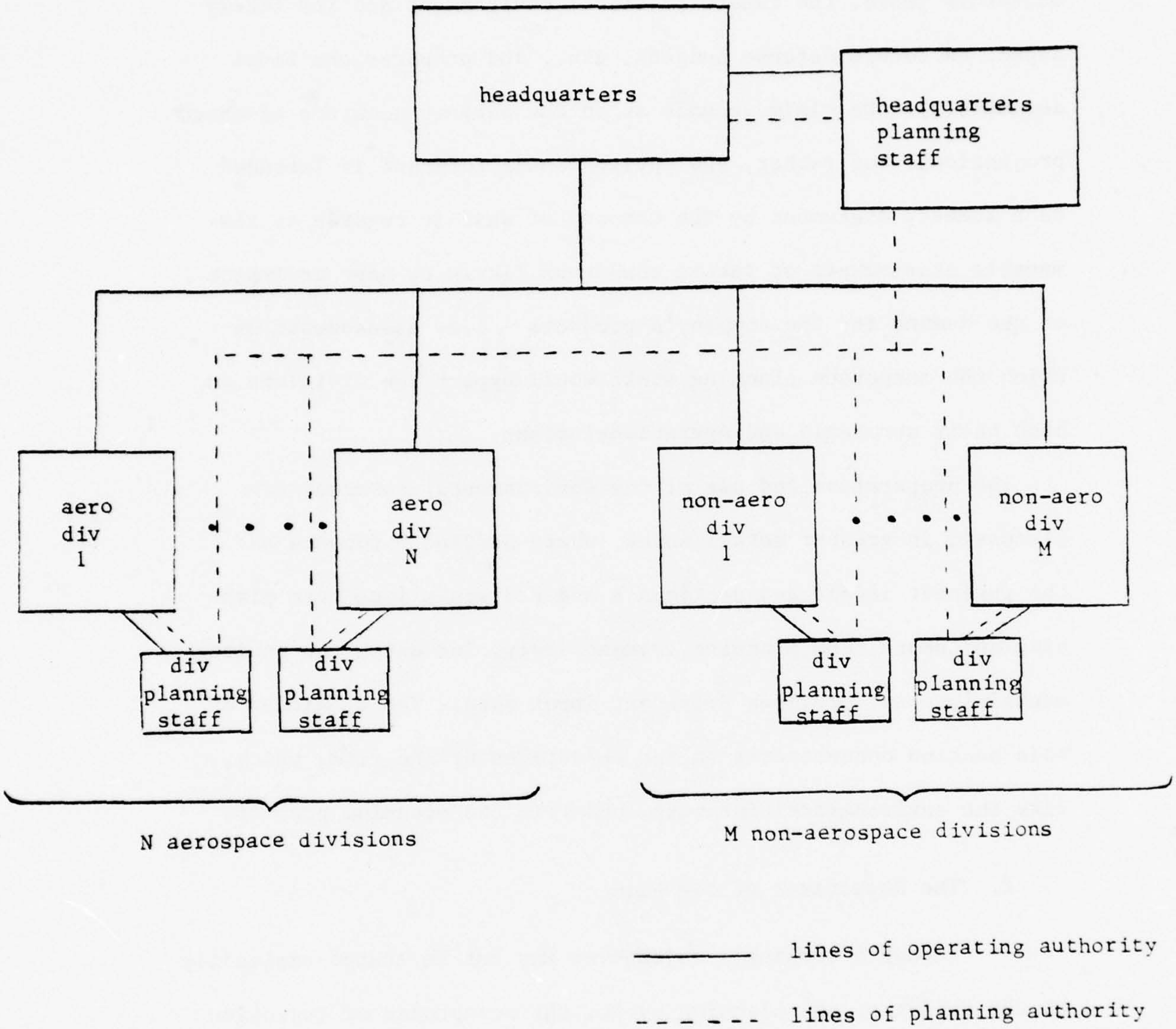

Figure 2: The Headquarters-Division Planning Relationship

in future years, the future political environment and its likely impact on future defense budgets, etc., and prepares the final document(s). No claim is made as to the perfect accuracy of these projections, but rather, the environmental forecast is intended as a summary statement by the company of what it regards as reasonable assessments of future conditons likely to have an impact on the demand for the company's products - i.e. assessments on which the corporate planning staff would expect the divisions to base their strategic and operational plans.

The preparation and use of the environmental forecast are discussed in greater detail below, where section D focuses on the forecast itself and sections E and F discuss long term planning and short term planning, respectively, for which the environmental forecast provides important input data. The remainder of this section concentrates on the objectives of the firm, which, like the environmental forecast, underlie the planning process.

2. The Objectives of the Firm

Though a company's objectives may not be stated explicitly at the outset of the planning cycle, the acceptance or rejection of divisional objectives and plans is based to a large extent on how well these objectives and plans support the company's objectives. Indeed, the divisional long term and short term plans finally accepted by headquarters and the specific goals they contain - a sales or output goal, a profit goal, etc. - are a reflection of corporate objectives. This subsection discusses the broad objectives of the nine major military airframe builders. While recognizing that

all corporations do not share identical goals, the author believes that there is sufficient commonality among the nine firms as to broad objectives to warrant the general treatment undertaken here.

Before describing the objectives of these firms, it will help to make that discussion more meaningful if the sources of the firms' objectives are discussed first. According to the traditional theories of the firm,[146] the objective of the firm is that of its shareholders, and the firm acts so as to maximize shareholder utility, which, under the appropriate assumptions, reduces to maximizing the stock market value of the firm's equity. According to an alternative point of view, as expressed by the managerial theories,[147] the objectives of the firm are set by top management, and profitability or the stock market value of equity affect managers only as constraints on their discretion to pursue alternative objectives. According to a third point of view, that of the behavioralists,[148] the firm's objectives are established through an internal bargaining process that takes place among the various special interest groups, for example, the labor force, the marketing staff, technical staff, shareholders, top management, middle management, etc., that compromise the firm and its 'owners'.

Based on personal interviews with executives of the nine firms, it is the belief of this writer that none of the three views discussed in the preceding paragraph is entirely correct. Rather, it is the author's view that the objectives of each firm are set by top management, principally the president and the chairman of the board of directors, together with the other members of the board of directors.[149] It is up to top management to weigh the specific

objectives of the various special interest groups, to resolve any conflicts that might arise, and to ensure compliance on the part of these groups with regard to the firm's established objectives. In particular, it is the board of directors, which includes representatives of shareholders and top management, rather than the shareholders themselves, that sets the firm's dividend policy and that also makes the major financial and investment decisions that affect the firm's future ability to pay dividends. It is also the board of directors that sets the compensation levels for top management. Of course, the relative weights assigned to a particular set of objectives could vary considerably from one firm to another, depending, for example, on the degree of influence of one or more key shareholders,[150] and could also vary over time for any one firm. Yet, the role of top management in establishing objectives would imply that, to the extent that the objectives of managers conflict with those of shareholders, shareholders' goals are not likely to be followed exclusively (in contrast to what the traditional theories have implied), and the role of the key shareholders in establishing the objectives of the firm would also imply that managers' goals are not likely to be followed exclusively either (in contrast to what the managerial theories have implied). Moreover, in establishing objectives, top management and other directors can take into account the desires of the various special interest groups within the firm, as suggested in the behavioralist approach, but in a manner suggestive of greater consistency in overall objectives over time than the behavioralists have implied.[151]

Broadly, the objectives of the nine major military airframe builders, as interpreted by this writer, fall into five classes: (i) sales objectives; (ii) a profit, or earnings, objective; (iii) a product quality, or in the case of weapons systems, weapons system performance, objective; (iv) a backlog, or new business, objective; and (v) a managerial emoluments objective. The first class consists of multiple objectives in order to reflect managements' desire to balance government and commercial business, while the other four classes consist of a single objective each. The remainder of this section is devoted to a discussion of these five classes of objectives.

The sales objectives reflect top managements' interest in size and diversification. In a model of the typical DOD airframe contractor to be developed in a subsequent paper, four sales objectives will be specified, one each for sales of aircraft and related parts and equipment to the government, sales of other products to the government, sales of aircraft and related parts and equipment to commercial buyers, and sales of other commercial goods. Alternatively, given the initial levels of these quantities, the four objectives could be restated in equivalent form as growth objectives. The reason for stating four sales objectives, rather than merely having two - one for government sales and one for commercial sales - or one - combining all sales figures into a single measure - is so that diversification between aircraft and non-aircraft products, as well as diversification between government and non-government sales, can be represented. As discussed in the previous section, several of the nine firms have in recent years

tried to develop new commercial non-aerospace ventures and two of the nine, LTV and Rockwell, are already widely diversified away from government sales and away from aircraft sales. In addition, all have some non-aircraft sales to the government - chiefly missiles and space equipment or ships. They are interested in diversifying in the two general directions mentioned above, though as David Lewis, Chairman of General Dynamics, recently made very clear, these firms are going to continue to actively seek government contracts to produce military aircraft,[152] and diversification is going to take place through the expansion of sales in commercial and non-aircraft ventures and not through the intentional contraction of their airframe business. It is felt by this writer that the value of increased sales in each of the four product areas as well as the importance of relative increases in non-government and non-aircraft sales - i.e. diversification - are best captured by stating multiple sales objectives.

The second objective, which relates to profits, is important for at least two reasons. Profits serve as an index of the efficiency with which management employs the firm's assets. Also, profits serve an important financial function. They represent the surplus of revenue over costs that may be used to pay dividends, and thereby satisfy the owners of the firm's equity shares, and, after dividends have been paid, the remainder represents retained earnings that may be used to finance new investment in plant and equipment or to acquire other firms.

The third objective, maintaining high product quality and

strong weapons system performance, is highly important to the managers of these firms, many of whom have engineering backgrounds and many of whose families, for example, the McDonnells and the Rockwells, have been in the aerospace business for generations. Product quality is so important also because each firm's managers want their company's name associated with technical excellence. Not only does such a reputation help foster a favorable public attitude toward the firm, but it also helps the company maintain its position as a prime contractor [153] and can contribute to sales of its commercial products that bear the company's name.[154] More importantly, high product quality and strong weapons system performance contribute to the firm's long run profitability.

The fourth objective, enlarging the business backlog, is particularly important in the case of aircraft sales, where production lead times are normally several months or more and where a temporary shutting down of a production line could cost several million dollars. A larger backlog provides some security and, as discussed below in section E, pushes the firm's going-out-of-business curve outward and makes the task of long term planning somewhat easier.

The last objective, managerial emoluments, reflects managements' interest in its own level of compensation. This includes not only salary, which is fully taxable, but also the perquisites, such as stock options, the earnings on which are taxed at the lower capital gains rate (provided, of course, the securities are held long enough to qualify for special tax treatment), and expense accounts, company cars, etc., which are not taxable.

In a later paper the four sales objectives and the profit, product quality, backlog, and managerial emoluments objectives will be used as arguments of a managerial utility function that will constitute the objective function in the mathematical programming formulation of the typical DOD airframe builder's planning problem. For the purposes of this descriptive paper, however, all these objectives will remain in the background. As part of the long term and short term planning processes described below, top management evaluates proposed projects in terms of the five classes of objectives,[155] and an important part of the two planning processes is the formulation of divisional goals and objectives, which top management reviews carefully and which, once approved by top management, are the focal point around which the divisonal plans are structured.

D. THE ENVIRONMENTAL FORECAST

1. The Corporate Planning Cycle

The corporate planning cycle for each of the nine major military airframe builders consists of the following three primary phases: preparation of the environmental forecast, development of the corporate long range plan, and specification of the corporate operating plan. These phases occur sequentially and together they span the company's entire fiscal year.[156] That is, planning for fiscal year T and beyond takes place throughout fiscal year T-1.

The primary phases of the corporate planning cycle are

illustrated in Figure 3. Each company's fiscal year is divided into four quarters. During the first quarter of year T-1 the environmental forecast is prepared. During the second and third quarters of year T-1 various long range planning studies are carried out and reviewed, culminating in the company's long range plan for years T and beyond. During the fourth quarter of year T-1 the operating plan for year T is established, essentially by specifying the first year of the long range plan in greater detail.

Qtr I Year T-1	Qtr II Year T-1	Qtr III Year T-1	Qtr IV Year T-1	Year T
prepare environmental forecast	formulate plan for and beyond	long range Year T	specify Year T operating plan	implementYear T operating plan begin a new planning cycle

Figure 3: The Corporate Planning Cycle

2. The Environmental Forecast: Its Purpose and Its Structure

The publication of the company's environmental forecast and its distribution among the firm's operating divisions initiates the planning cycle. The form and content of the environmental forecast may vary from one company to another. In some cases the forecast is a formal document that carefully analyzes and weighs political, social, economic, and business factors that may in the future have an impact on the firm. In other cases it is an informal paper prepared by a small staff who gather information and supporting data from a variety of public and private sources to highlight those significant

factors likely to affect the firm in the future. In either case the purpose of the environmental forecast is the same.

The purpose of the environmental forecast is, as its name suggests, to summarize within a single document the company's prognosis of the most likely external business environment within which it can expect to operate over its long term planning horizon. More importantly, the environmental forecast establishes a common set of assumptions that, when used in the next two phases of the planning cycle, give the plans of the individual operating divisions a vital degree of consistency that would otherwise be lacking.

The environmental forecast is written in conjunction with the firm's operating divisions, each of which is asked to submit to the corporate planning staff early in the first quarter information within its area of expertise that is relevant to its planning problem. Such a procedure has two main advantages. First, the divisions are involved in the planning process very early in the planning cycle and, since they provide much of the information on which the environmental forecast is based, they are more likely to view the environmental forecast's projections as reasonable than they would if the projections had been developed by the corporate planning staff without consultation. Second, the corporate planning staff can utilize the marketing expertise that is available in the divisions, thus enabling them to spend more time on analysis, rather than on data collection.

The structure of the environmental forecast varies from one company to another, depending on the needs of divisional planners.

Generally, the forecast treats three main subject areas. First, it describes the international environment and how such factors as international political tensions and international economic trends are likely to affect world demand for military aircraft. Second, it discusses the domestic political and economic environment and projects the size of the defense budget over the long term planning horizon. Of particular concern to the company is how changes in the defense budget might affect the company's current military programs as well as any future military programs on which the company is planning to bid. Third, it discusses factors relevant to the specific product markets, both military and commercial, in which the company sells its goods. For example, if the company produces commercial aircraft, such factors as the expected future growth of airline passenger traffic, the expected future growth of air cargo shipments, the expected future impact of fuel price changes, and regulatory trends, would, to the extent that meaningful projections can be made, give planners in the commercial aircraft division a good planning base from which to work.

A useful by-product of the process leading to the environmental forecast is a set of analyses, one for each operating division, of the strengths and weaknesses of the company's operations. Each such analysis assesses such factors as the strengths and weaknesses of that division's products in relation to the products of the firm's major competitors (in the case of commercial products) and problems that might arise in connection with government contracts (in the case of military weapons systems). The analysis of the division's

strengths and weaknesses is used by the divisional planning staff in conjunction with the environmental forecast that comes down from the corporate planning staff near the end of the first quarter to formulate the division's long term plan.

E. LONG TERM PLANNING: PORTFOLIO SELECTION AND THE GOING-OUT-OF-BUSINESS CURVE

1. Introduction

The second phase of the corporate planning cycle consists of long term planning. The purpose of long term, or strategic, planning is to determine the corporation's business strategy over the long term planning horizon - typically a period of five years' duration. The long term planning process leads to a long term plan for each of the firm's operating divisions that is consistent with the corporation's goals and objectives and that spells out that division's role - i.e. its business strategy - in meeting the company's goals and objectives.

This section describes the long term planning process that is followed within the nine major military airframe builders. At the outset it should be noted that long term planning, as practiced by these firms, is not designed to lead necessarily to an 'optimum' plan. The planning process is an iterative one, as described below, though the iterations are designed to achieve feasibility and robustness rather than to ensure optimality. During the long term planning process headquarters and the operating divisions search for a long term plan - essentially a collection of business

strategies together with the facilities, financial, research and development, and manpower requirements needed to support them - that is *feasible* in the sense of leading to the attainment of corporate goals and objectives if the 'expected' environment (as described in the environmental forecast) materializes and that is also *robust* in the sense that the plan will also permit the firm's goals and objectives to be attained if the business environment in general, and market conditions in particular, should vary from what is expected in a manner that top management perceives as reasonable.

The fact that these firms do not strive for a plan that is optimal - in the sense that it leads to a higher level of managerial utility, a higher stock market value of the firm's equity, or a higher value of some other function or quantity than any other feasible plan - is due to at least two factors, each of which was mentioned by several of the executives interviewed by the author. First, gathering the information required to formulate the long term planning problem as an optimization problem, say as a mathematical programming problem, would, in the opinions of virtually all the executives interviewed, be prohibitively costly in terms of time and money.[157] Second, even if the problem could be formulated in a manner acceptable to top management, a solution would have to be obtained, and in the opinion of most of the executives interviewed, the size and complexity of the problem would make it prohibitively costly to find the solution.[158, 159] These cost considerations would imply, if they are correct, that even though the long term plans that are developed are not necessarily optimal,

the planning process itself may be optimal - in the sense that, of all the procedures available for achieving any particular set of feasible and robust plans, it involves the least cost.[160] This question of the optimality of the planning process will be explored further in a subsequent paper.

2. Long Term Planning at the Divisional Level [161]

At approximately the same time the corporate planning staff releases the environmental forecast - late in the first quarter or early in the second quarter - top management distributes among the company's operating divisions a statement of the corporation's long term goals and objectives and a set of strategic guidelines. From this point onward in the corporate planning cycle, the primary organizational responsibility for planning shifts from headquarters to the operating divisions. The corporate planning staff continues to be involved in the planning process, but its role involves coordinating the planning efforts of the divisions, analyzing the plans of the divisions, and amalgamating the plans of the divisions for review by top management. The long term plans themselves are prepared at the divisional level.

The long term planning process as carried out at the divisional level is illustrated in Figure 4. The process begins with the environmental forecast that establishes the projected future states of the firm's operating environment and with the statement of corporate goals and objectives and the set of strategic guidelines handed down by top management. The environmental forecast together with the set of strategic guidelines specify the constraints imposed by

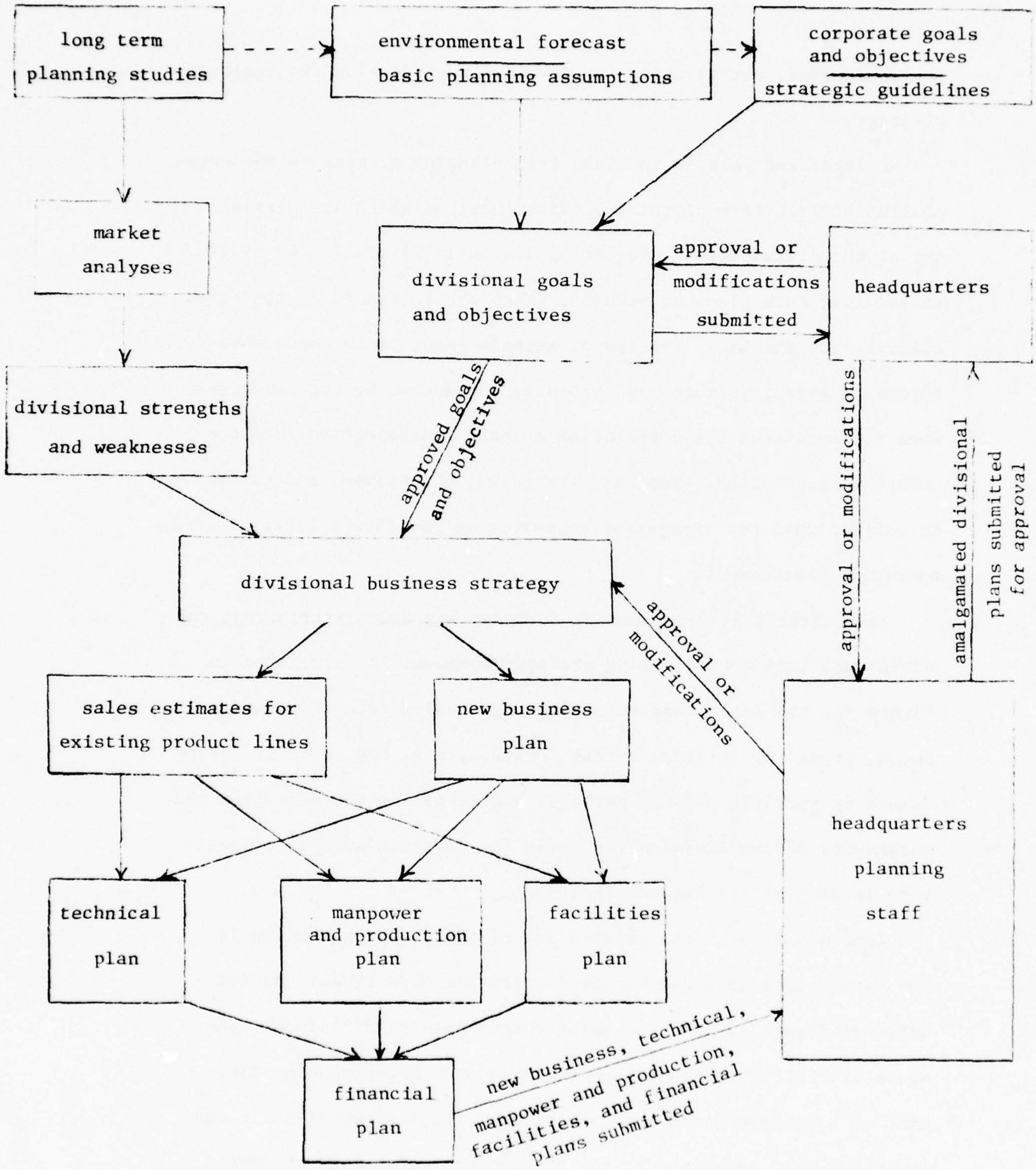

Figure 4: The Divisional Long Term Planning Cycle

top management, within which the division must develop its business strategy.

An important part of the long term planning process is the preparation of long term planning studies, most of which are carried out at the divisional level. As indicated in Figure 4, the divisional long term planning studies, which are initiated in the first quarter, are the basis for the division's input to the environmental forecast, which, in turn, is carefully considered by top management when it formulates the corporation's goals and objectives and the strategic guidelines. That is, the goals, objectives, and guidelines do reflect what top management perceives as the firm's likely future operating environment.

Even after the environmental forecast has been distributed, the divisional long term planning studies continue. As indicated in Figure 4, the later long term planning studies generally narrow in focus, providing specific market analyses, e.g. the state of future demand in specific product markets, and detailing the strengths and weaknesses of the division vis-à-vis the division's major competitors in each of its product markets.

Concomitant with the preparation of the planning studies is the formulation of the division's goals and objectives. As indicated in Figure 4, the two major inputs used by divisional managers are the environmental forecast and top management's statement of corporate goals and objectives. The divisional goals and objectives are submitted to top management, which must approve them before long term planning can proceed any further.

After the divisional goals and objectives have been approved and the division's long term marketing studies and its assessment of its strengths and weaknesses have been completed, the division's management prepares the division's long term business strategy for achieving its goals and objectives, and by implication, for achieving the goals and objectives of the corporation. The business strategy covers such items as product design, pricing policy, development of new customer relationships, etc., for existing product lines as well as its strategies concerning new product lines, i.e. in which direction(s) it intends to diversify, what new product lines it intends to develop, when the new products should be introduced to the market place, for what upcoming government programs it intends to bid, etc. From the divisional business strategy flows sales estimates for existing product lines and the new business plan.

Generally, the business strategy is developed and sales estimates are generated and the new business plan is formulated by product line and by government contract. Often the corporation's principal operating units will consist of several subdivisions each, with each subdivision responsible for one or more individual product lines. One of the tasks assigned to the planning staff of the division - i.e. the principal operating unit [162] - is to integrate the various sales estimates provided by these subdivisions with the new business plan for the division in order to establish the following plans: (i) the technical plan, which lists the technical requirements and the size of the technical staff and the amount of funds needed to support the division's

research and development effort; (ii) the manpower and production plan, which lists planned output and the numbers and cost of production and managerial personnel needed to meet these targets; and (iii) the facilities plan, which lists the types and amounts of plant and equipment needed and the costs of maintaining existing facilities and investing in new facilities.[163] These three plans, together with sales estimates and the new business plan, are used to generate the division's long term financial plan.

Once completed, the financial plan, together with the new business, technical, manpower and production, and facilities plans, are submitted to the corporate planning staff, which reviews the division's plans. If the corporate planning staff is not satisfied, for example, because the plan contains inconsistencies or because the division appears to have deviated too far from the assumptions contained in the environmental forecast, it sends the plan back to the division. If the corporate planning staff accepts the plan, it then amalgamates the plan with the plans of all the other operating divisions. The amalgamated plans form the provisional corporate plan, which is submitted to top management for its approval. Top management reviews the provisional corporate plan as well as summaries of the divisional plans and checks for consistency with corporate goals and objectives. Specifically, top management checks the provisional corporate plan for feasibility - i.e. will the plan enable the corporation's goals and objectives to be attained? - and for robustness - i.e. if the plan is

carried out, but environmental conditions change from what has been anticipated, how seriously will the corporation's ability to meet its goals be impaired? Top management is also likely to check for other desirable characteristics, such as flexibility - i.e. is the plan sufficiently flexible that certain actions can be postponed without having severe consequences for other parts of the plan, or does the plan call for substantial irreversible investments very early in the planning period? If any of the divisional plans require modification, they are returned to the division. As indicated in Figure 4, the division will probably have to alter its business strategy. Once the long term plan has been accepted by headquarters, the long term planning phase of the corporate planning cycle has been completed.

The above description of the long term planning process was intentionally kept general in order to give the reader an intuitive feel for the overall process. The remainder of this section looks at important aspects of this overall process more closely.

3. Long Term Planning: Government Sales and the Going-Out-Of-Business Curve

The description of the long term planning process provided in the preceding subsection did not distinguish between government sales and commercial sales. In Figure 4 government sales and commercial sales were lumped together in the blocks labeled 'sales estimates for existing product

lines' and 'new business plan'. Yet, because of the important differences between doing business with the government and doing business with commercial customers, which were discussed in section B, the long term planning process must treat these two classes of sales somewhat differently. This subsection discusses long term planning for government sales, and the next discusses long term planning for commercial sales.

Long term planning, as it relates to government sales, involves the two types of planning indicated in Figure 4: (i) planning for the future resource requirements implied under existing government production contracts and under anticipated follow-on government production contracts and (ii) determining the upcoming government programs on which to bid and planning for the resources - particularly technical staff and research and development facilities requirements - required to launch a successful bid for each. One of the devices planners use to illustrate both aspects of government sales planning is what is called the going-out-of-business curve, an example of which is the heavy curve in Figure 5. The going-out-of-business curve shows what would happen to government sales if current programs were not extended beyond their present termination dates and if no new programs were won. If the viability of the division were heavily dependent on government sales, then a lack of extensions and an absence of new programs could literally drive the division out of existence (and hence the curve's name). The sales impact of new programs the division

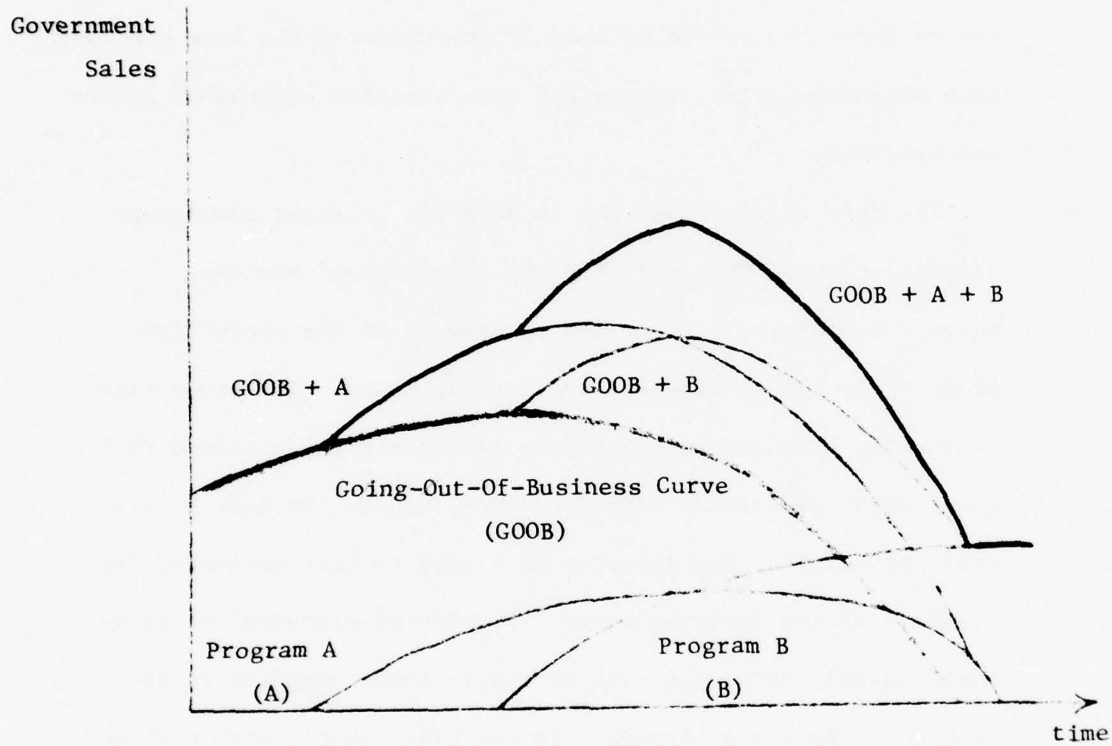

Figure 5: Going-Out-Of-Business Curve With Overlays

hopes to win and contract extensions it hopes to be granted can be overlaid, as shown in the figure, to provide a graphical representation of government sales for each year covered by the long term plan. Each of the modified going-out-of-business curves shows the growth pattern of government sales over the long term planning period, contingent upon contract extensions and/or new programs.

The type of planning that is done for existing government programs - those that underlie the going-out-of-business curve - depends on whether the program is in the production stage or in the development and testing stage. For production contracts, planning is relatively easy since the required technical advances have already been made, and in the case of aircraft production, the division is likely to have estimated the position of the learning curve. Production planning, which is based largely on projections of future needs supplied to the contractor by the government, is concerned mainly with manpower and facilities needs. In aircraft production the direct labor input per airplane will fall as the cumulative number of aircraft produced increases due to the learning curve effect discussed in section B. A second factor that needs to be considered in production planning is the program's peak production rate - seldom do programs call for a uniform production rate - for this can affect the need for plant floor space and storage space for inventories of parts and equipment. A third factor is the program's termination risk. If termination occurs, the divison

will find itself with excess capacity unless some contingency use for the facilities has been planned. However, according to the executives interviewed by the author, estimation of the termination risk is so highly subjective as to be, in practice, of little use. In addition, the overcapacity that exists throughout much of the industry [164] and the limited alternative uses to which these production facilities can be put, imply that termination will in most cases result in additional sparce capacity until such time as a new program can be won.

For development and testing contracts the planning required is more difficult than for production contracts because the division and the firm are interested in making the required technical advances within the required time and within the projected costs. The prediction of the resources - mainly engineering and design personnel, development facilities, and the facilities and manpower required to assemble the test and evaluation aircraft - needed to develop the product called for under the contract is inherently more difficult than projecting production resource requirements and costs. Even though development and testing contracts are typically of the cost-plus variety, thereby reducing the firm's share of the overall cost risk below what it would be under a fixed price contract, the contractor is anxious that its customer - the government - be satisfied with the final product. It is important that the product perform well enough and that its cost of production be kept low enough that production funding will not be threatened.

Indeed, several executives told the author that their companies would make additional improvements not called for in the contract, possibly even when there was virtually no chance of immediate reimbursement for costs incurred, in order to improve the product's performance and thereby increase the likelihood of a larger and longer production run.

The type of planning that must be carried out for new programs - planning that involves the allocation of scientific and research talent, the allocation of IR&D funds plus the company's own research and development funds, and the allocation of engineering and design personnel and manpower and facilities to be used in the development of such items as prototypes that will be flown in a competition to determine the winner of relatively more lucrative production contracts - is more difficult than the planning that is conducted for existing programs. The uncertainities and business pressures are normally greater since the division is interested not only in meeting the specifications of the research and prototype development contracts assigned to it by headquarters, but also in placing the company in an advantageous position for any follow-on contracts.

The efficient allocation of research and development funds and personnel is of critical importance to the firm because of the long lead times required for research and development and also because of the small number of new major programs. In planning their research and development program, the division and the company must have some conception of what the government's needs will be many years in advance. For this reason, long term planning

studies often try to look out beyond the Department of Defense's Five Year Defense Plan in order to predict the military's needs far enough in advance to permit the necessary research to be undertaken.[165] In other words, one of the responsibilities with which divisional planners are charged is the responsibility of allocating 'pure research' moneys - some of which are reimbursed through IR&D awards - in such a way that the company (and the division) will have accumulated a sufficient store of technical and scientific skills by the time a new program is formally announced to be competitive in its attempt to win the program.

In allocating the research and development resources over proposed new programs, divisional planners must analyze the risks and potential returns associated with possible new programs and allocate the resources to those programs most likely to lead to accomplishment of the division's goals and objectives. Generally, it is impossible for a company to bid competitively on every major new program, so selectivity is required, and typically, the decision as to the major new programs the company is going to try to win will be made by top management and will be incorporated within the company's and within the appropriate division's goals and objectives. It is then up to that division's managers and planners to allocate the division's research and development resources to meet those goals and objectives.[166]

4. Long Term Planning: Commercial Sales

As in the case of government sales, planning for

commerical sales is best treated as two types of planning: (i) planning resource requirements for existing product lines and (ii) planning resource requirements for new business, including both new products, e.g. a new generation of commercial passenger aircraft, and new lines of business, e.g. the acquisition of another company as part of a diversification strategy. Both aspects of commercial sales planning are discussed below.

In general, the factors that must be considered when planning commercial sales are different from those that must be considered when planning government sales. Variations in government sales are due to changes in the needs of the sole customer or to changes in the sole customer's ability to purchase weapons that result from changes in the levels of Congressional funding of major weapons system programs, which in turn can often be traced to political factors, i.e. to the political cycle. In contrast, commercial sales are made to a variety of customers who select from among a variety of products that can meet their needs and whose ability to pay is largely affected by the condition of their balance sheets and by the state of demand for their goods and services, which in turn can be traced to a variety of economic factors, i.e. to the business cycle.

Long term commercial sales planning for existing product lines requires a careful analysis of each competitor's products, and unlike sales of existing products to the government, which take place under conditions of bilateral monopoly, commercial markets, such as those for commercial passenger aircraft, are

usually served by a number of producers, each of which carefully watches its market share - its percentage of total market sales. In the case of commercial aircraft, planning for production is similar to planning for the production of military aircraft in that the learning curve effect must be taken into account. However, whereas a single contract for military aircraft will specify the delivery schedule, and by implication, the production schedule, for that aircraft for a year, the production schedule for commercial aircraft is typically less certain since the number of customers is much greater; since the continued ability of each purchaser to pay for the planes it has agreed to buy is somewhat less certain; since each commercial customer's purchase of a particular aircraft is more easily postponed both because commercial aircraft can be leased and because the introduction of a new commercial aircraft does not normally have associated with it the sense of urgency that typically accompanies the introduction of a new military aircraft; and since a potential sale can be lost to one of the commercial producer's competitors. Hence long term planning for sales of commercial aircraft, as well as for sales of other commercial products, requires contingency planning in the form of 'high' and 'low' sales estimates for each year, in addition to the 'best' estimate of future sales for each year. In the case of commercial aircraft, the best estimates are obtained after careful analyses of trends in first, commercial airline passenger traffic and second, in the future demand for air cargo shipments have been performed. These analyses are used to project future commercial airline fleet

requirements for new aircraft, and in light of financial projections, to predict the likely demand for new aircraft in each year over the long term planning period. The 'high' and 'low' estimates may be obtained by applying some simple rule of thumb, such as 'add 10 percent to the best estimate to obtain the high estimate and subtract 10 percent from the best estimate to obtain the low estimate for each year'. Alternatively, high and low estimates may be obtained by varying the assumptions on which the best estimates were based and by applying the same estimation procedures to an 'optimistic' set of assumptions and to a 'pessimistic' set of assumptions. As illustrated below by Figure 6, this results in three sets of demand projections for each year, one for each of three states of nature: the expected state, as specified in the environmental forecast, the optimistic state, and the pessimistic state.

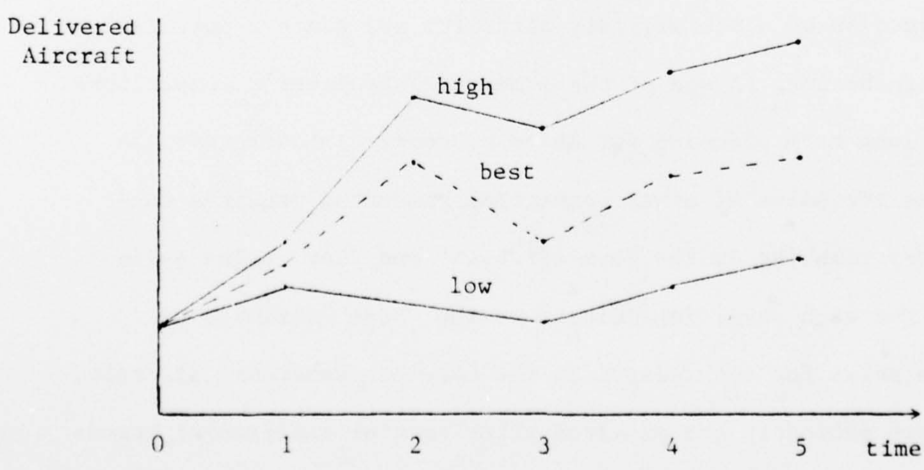

Figure 6: Projections of Long Term Demand for Commercial Aircraft

One of top management's more difficult decisions, which can greatly affect the long term plan, is the decision regarding

what to do when the demand for a particular commercial airplane has been very weak and threatens to remain weak for some time. Commercial aircraft sales are generally made on a contractual basis, but when the financial positions of the commercial airlines worsen seriously, as they have in recent years, the airlines are loath to enter into long term contracts.[167] In the absence of long term contracts or some other indication of likely future demand, the commercial airplane maker has essentially three choices: (i) to continue production at a low rate and hope that future sales will materialize,[168] (ii) to introduce product variations, such as a 'stretch version' of the airplane - to try to increase sales,[169] or (iii) to close down the production line. The first two choices involve additional costs and potentially large financial risks,[170] while the third may require a massive write-off that can adversely affect the firm's financial health over a period of several years.[171]

Planning for new commercial business involves, as in the case of planning for new government programs, considerably greater uncertainty than planning for sales of existing products. In the case of a new generation of commercial passenger aircraft, there are the risks discussed in section B. The initial investment required often exceeds the company's net worth, and if the introduction of the new plane has been poorly timed or if potential demand for such a plane has been seriously overestimated, the company's viability may be threatened. In planning for diversification into new product lines

there are several factors that need to be considered. These include the product line's compatibility - in terms of the nature of the product and the requirements for marketing it - with existing product lines, the need to hire production and staff workers, the need to purchase equipment, and the financial resources that will have to be tied up in the new product line. In addition, if diversification is to take place by external means, there is the problem of selecting a takeover candidate and launching a successful bid for a controlling interest in the firm. Normally these decisions and the required financial arrangements are made at the headquarters level, although the formulation of the technical, manpower and production, facilities, and financial plans involving the new product line are the responsibility of the division to which the new product line has been assigned.

Once the sales estimates and new business plans for both commercial sales and government sales have been prepared and reviewed by divisional management, divisional planners can derive the technical plan, the manpower and production plan, and the facilities plan for the division as a whole, and then from these, the division's financial plan. From there the long term planning process proceeds as described in subsection 2 of this section.

5. Long Term Planning: Human Capital and Fixed Capital

The preceding subsection explored several of the important planning considerations that underlie the blocks

labeled 'sales estimates for existing product lines' and 'new business plan' in Figure 4. This subsection deals with the next stage in the divisional long term planning process, and in particular, with the technical plan and with the facilities plan. The former is primarily concerned with the allocation of the division's scientific and engineering talent - human capital - whereas the latter is mainly concerned with the allocation of plant and equipment - fixed capital.

The economic literature in recent years has contained many books and papers that have explored the economic significance of human capital.[172] The purpose of this section is not to review that literature, but rather, it is first, to characterize human capital and to indicate its importance to the major military airframe builders, and second, to indicate how the existence and importance of human capital affect the long term planning process in these firms.

Following Schultz and others, a firm's 'human capital' is defined as the scientific and technical knowledge and skills embodied in the scientists, engineers, designers, and technicians who work for the firm.[173] In contrast, fixed capital consists of durable goods such as plant and equipment.[174] Both types of capital are valued by the firm for the services they provide. In the case of human capital, there are the services provided during the research and development phases of a weapons system program, and in the case of fixed capital, there are the services provided during the production phase of

the program.[175] In addition, both types of capital normally require an investment on the part of the firm. Fixed capital is normally purchased and maintained by the firm, although firms often lease plant and equipment,[176] while human capital must be accumulated through research and development activities funded, at least in part, by the firm, although firms can in a sense lease human capital by hiring engineers and scientists who have worked on similar projects for other aerospace firms.[177]

There are also important differences between human capital and fixed capital. First, human capital tends to accumulate through use (i.e. experience) as skills and techniques are acquired and as valuable lessons are learned from past mistakes, whereas fixed capital tends to deteriorate through use. Second, the typical airframe builder tends to enjoy greater flexibility in its use of human capital than in its use of fixed capital. Human capital can be gained or disposed of through the hiring or laying off, respectively, of an individual, whereas fixed capital, which comes in larger units, typically requires much greater cash outlays when acquired and, because of the limited alternative uses for much of the equipment, often can be sold only at a loss. Third, knowledge and skills are transferable so that improvements in human capital can be transmitted from one individual to another, whereas embodying technological improvements in machinery more often requires that a completely new machine be built. Fourth, due to differences in individual learning ability and due also to the importance of recent

experience on similar projects to the learning effect that underlies the growth of human capital, the quality of human capital about to be hired by a firm is generally more difficult for a manager to evaluate than the quality of a piece of equipment for which engineering specifications and various test data are available.[178] Fifth and last, it is possible to order a particular piece of equipment or a plant meeting certain specifications, but to hire an individual with the requisite scientific background and experience can involve a costly and time-consuming search process. It should be noted that the last two factors are two of the major reasons why the major airframe builders are anxious to stabilize their scientific, engineering, design, and technical staffs.

The importance of human capital to the major airframe builders lies in the role each firm's scientists, engineers, designers, and technicians play during the research and development phases of a major weapons program. As discussed in section B, the development of a new generation of aircraft typically calls for several advances in the state of the art. Second, the military buyer typically outlines its needs for a new weapons system, but leaves it up to the several firms willing to enter the competition for the program to submit specific designs. Similarly, the development of a prototype requires a great deal of engineering and design work, and as the performance and overall effectiveness - i.e. the quality - of what is produced weighs so heavily in the final decision,[179] the firm's success in winning new programs is heavily dependent on how well its scientists, engineers,

designers and technicians perform.

The implications of the critical role played by human capital for the long term planning process of the major airframe builders are first, that scientists, engineers, designers, and technicians are treated as a class of labor distinct from production workers, and second, that these highly skilled workers are treated more like fixed capital than like labor. That is, planners make a conscious effort to time phase major programs in such a way that the staff embodying human capital can remain fully employed and reasonably stable over time.[180] It may also mean that, on occasion, a firm will bid on a program or on a piece of a program, at least in part, because it needs work to provide stable employment opportunities for its scientific and technical staff.

Due to the overcapacity throughout much of the airframe industry, which was discussed in section B, as well as the paucity of new major weapons programs, it is the allocation of human capital, rather than the allocation of fixed capital that is the more critical capital allocation problem facing these firms' planners. In particular, the decline in aircraft sales since 1968 has forced over 70,000 scientists, engineers, and technicians to leave the industry,[181] many of them for good, and this decline in the pool of available talent has made the airframe builders increasingly reluctant to release these people for fear that in the future they might not be able to rehire sufficient numbers when the need arises. While

under more favorable business conditions, with demand pressing against capacity, the airframe builders would also face the problem of having to decide how to allocate spare productive capacity and the decision as to whether to expand productive capacity, the fixed capital allocation problem is not a pressing one at the present time.

6. Long Term Planning as a Portfolio Selection Problem

Up to this point in this section, the discussion has been mainly descriptive, rather than analytical, and has focused on long term planning at the divisional level. This subsection considers long term planning at the headquarters level and suggests that, in reviewing the amalgamated divisional plans, top management approaches the long term planning problem in much the same way that an individual investor approaches the problem of selecting the portfolio of securities that, in terms of his relative risk aversion, provides the proper balance of risk and return.

As indicated in Figure 4, once the division has completed its financial plan, which lists the financial requirements implied by its technical, manpower and production, and facilities plans, it submits these four plans together with the new business plan to the headquarters planning staff for their review. The headquarters planning staff may require that certain divisions modify their plans. After the required modifications have been made to the satisfaction of the corporate

planning staff, the divisional long term plans are amalgamated into a provisional corporate long term plan, which is typically broken down into a corporate new business plan, a corporate technical plan, a corporate manpower and production plan, a corporate facilities plan, and a corporate financial plan, each of which is, with the exception of the corporate financial plan, an amalgamation of the respective divisional plans.

In addition, there may be one or more divisions that perform support, rather than operational, duties. For example, there may be a computer services division that provides for all the data processing needs of the operating divisions but does not sell to outside users. Even if it sells to outside users, these sales may be peripheral to the division's support function. In that case, the headquarters planning staff may find it more efficient from a planning standpoint to have the support division estimate only the external demand (if any) for its services and to estimate the internal demand for the support services at the same time it amalgamates the plans of the operating divisions. External and internal demands for support services would then be combined and the various provisional corporate plans would be revised accordingly. Finally, the provisional corporate plans are prepared in summary format for review by top management and are then forwarded for their scrutiny.

One of top management's greatest concerns is the corporate financial plan, which indicates the financial needs of the corporation over the long term as well as the anticipated impact

of the new business, technical, manpower and production, and facilities plans on the firm's financial statements. In addition, since all funds generated internally that are available for distribution as dividends or for reinvestment are allocated by top management, and since all funds that are raised externally must be raised through the issuance of debt or equity financial instruments or through a loan agreement with one or more banks, in either case handled through the corporate controller, it is necessary to add top management's plans for obtaining the financial resources - i.e. the money capital - needed to fund the activities of the operating divisions to the amalgamated divisional financial plans.

In reviewing the corporate financial plan and the other four plans that comprise the overall corporate long term plan, top management faces a multiperiod portfolio selection problem. Associated with each of the product lines that the divisions plan to continue and also with each of the new business ventures planned are (i) an expected return - a contribution to corporate net operating income - for each year out to the long term planning horizon and (ii) various risks, which fall within the categories discussed in section B. These risks can have a major impact on the corporation's overall financial risk. In addition, the product lines and projects must also be evaluated in terms of the contribution of each to the other objectives of the corporation. The firm's present financial health as well as its capacity for borrowing limit the extent to which current

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commitments can be undertaken, thereby imposing a "budget constraint," while current commitments will affect future earnings and future borrowing capacity, which in turn will limit the extent to which future commitments can be undertaken.

The foregoing suggests what the author believes may turn out to be an interesting analytical approach to understanding the typical airframe builder's long term planning problem. It is the author's intention to explore this possible approach further in a subsequent paper.

7. Summary

This section has described the typical airframe builder's long term planning process - the second of the three phases of the corporate planning cycle. Key elements in the planning process were highlighted, the special treatment accorded human capital was discussed, the headquarters planning staff's role in coordinating divisional planning and in amalgamating divisional plans in order to prepare an overall corporate long term plan for review by top management was described, and the formulation of the corporate long term financial plan was discussed. In addition, an analytical approach to modeling top management's role in the long term planning process was suggested.

The next section describes the short term planning process and indicates how consistency between the long term plan just discussed and the short term plan is achieved.

F. SHORT TERM PLANNING: ANNUAL BUDGET PREPARATION

1. Introduction

The third phase of the corporate planning cycle involves the preparation of the short term, or operating, plan, which is generally carried out for the first year of the long term planning period only.[182] The annual operating plan, which for reasons of consistency, is derived from the corporate long term plan, provides much greater detail for the period covered than does the long term plan.

The annual operating plan is presented in the form of a detailed budget.[183] Unlike the long term plan, which is mainly concerned with the allocation of capital resources and with the development of strategies and plans whose main impact will be on sales and earnings five years or more into the future, the short term plan is mainly concerned with the allocation of variable resources and with the development of strategies and plans that will largely determine sales and earnings within the next year. Whereas the long term plan is heavily concerned with developing new product lines to replace those that will eventually be phased out and with winning new programs to replace those that are due to expire, the short term plan is heavily concerned with controlling direct costs and overhead cost for the firm's current commercial and military product lines. Also unlike the long term plan, which generally summarizes projections on a year-by-year basis,[184] the short term plan is presented on a month-by-month basis.

This section describes the short term planning process that is followed within the nine major military airframe builders. As was the case with the long term planning process, most of the short term planning takes place at the divisional level, with the headquarters planning staff once again coordinating divisional planning efforts and with top management once again carefully reviewing the final product of this phase of the planning cycle.

2. Short Term Planning at the Divisional Level

After top management has approved the corporate long term plan - normally late in the third quarter - the short term planning process can begin. This process begins much as the long term planning process was begun, namely, with the distribution of the corporation's short term goals and objectives by top management. These short term goals and objectives are generally more specific than the long term goals and objectives and are normally accompanied by a set of specific guidelines for divisional short term planning. For example, the long term plan is likely to specify an overall profit margin, i.e. the ratio of net operating income to net sales, for each year, while the short term plan is likely to specify the profit margin (or more specifically, the 'contribution margin') for each product for the coming year. To ensure consistency with the corporate long term plan, these goals and objectives and guidelines sent out from headquarters are based on the approved corporate long term plan. As was the case with long term planning, from this point in the short term planning

process onward, most of the actual planning takes place at the divisional level.

Figure 7 illustrates the short term planning processes as it is typically carried out at the divisional level. The process begins with a statement of the assumptions on which the divisional short term plan is to be based and with the formulation of the division's short term goals and objectives. The planning assumptions flow directly from the corporate and divisional long term plans, and the goals and objectives follow from the divisional long term goals and objectives embodied in the corporate long term plan and the more specific corporate short term goals and objectives and planning guidelines supplied to the division. As in the case of the long term planning process, headquarters approval of the division's goals and objectives is required, although such approval is less problematical than in the long term case because the basic direction and strategies for the corporation and for the division have already been mapped out during the long term planning process.

Once the division's short term goals and objectives and planning assumptions have been approved, the goals and objectives together with the divisional business strategies approved as part of the long term planning process are used by divisional management to formulate the division's short term business strategies - the collection of policies that specify the division's competitive position vis-à-vis its competitors in each of the commercial markets in which it sells and its approach to contract negotiations with the government. It needs to be emphasized that great care is

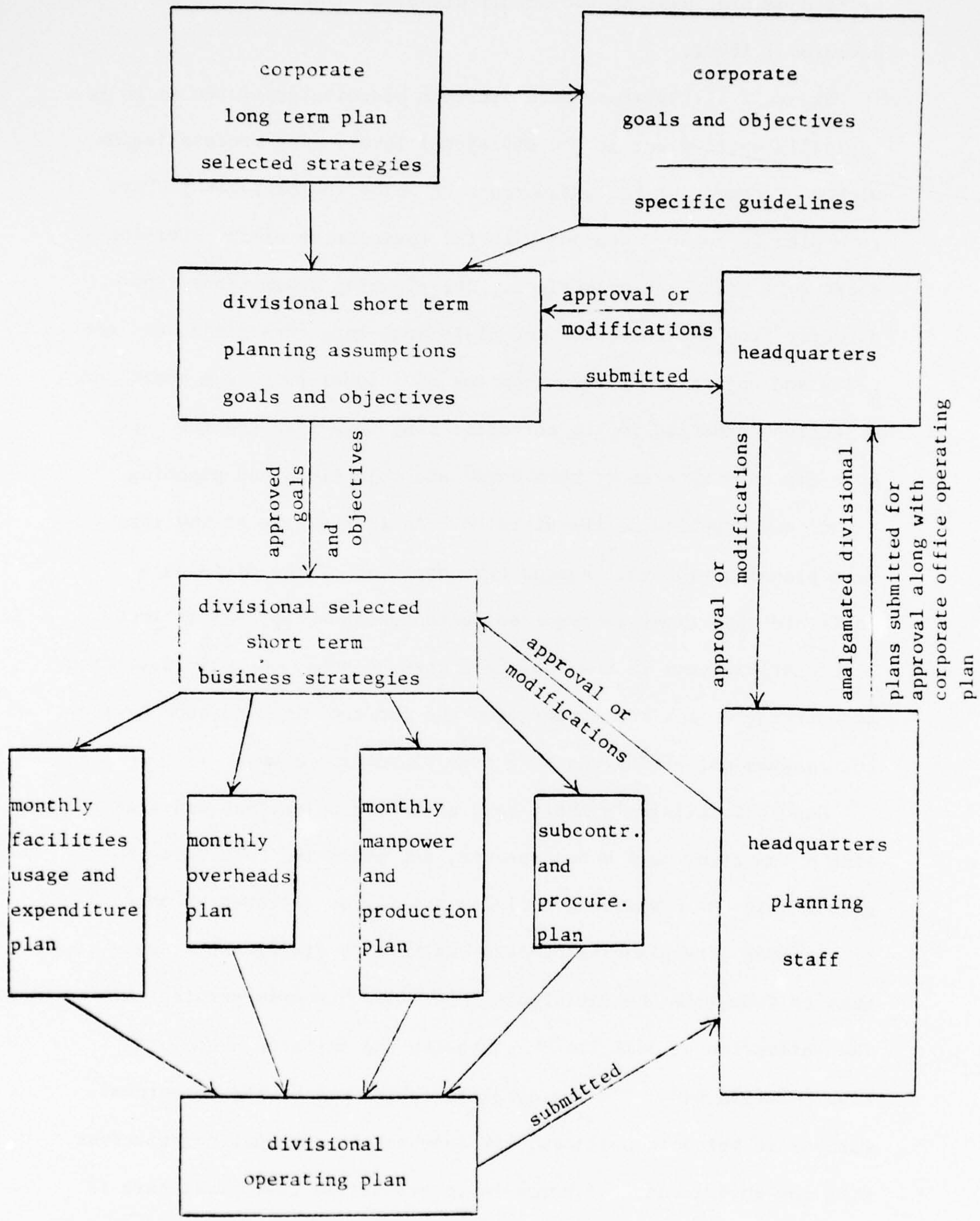

Figure 7: The Divisional Short Term Planning Cycle

taken to ensure that these short term strategies are consistent with the long term strategies that underlie the long term plan. For example, not altering the design of a particular product, say a particular type of aircraft, may enable the division to avoid the expense involved in design changes, and thereby boost the division's overall profit margin, though the failure to 'modernize' the airplane may hurt future sales and profits in the event competitive pressures or a change in government regulations force these changes to be made hurriedly.

After establishing the division's short term business strategies, divisional management directs the division's planning staff to collect the information needed to determine the actual resource requirements of the division and to plan how these requirements will be met. This part of the short term planning process results in several component plans, which, for convenience, have been grouped into four component plans in Figure 7. The monthly facilities usage and expenditure plan indicates the plant and equipment allocated to each product line - whether government or commercial - for each of the twelve months covered by the operating plan. It also indicates the time of arrival and use of new equipment that will be purchased and the beginning of operation and use(s) of new plant that will become available during the year. The monthly overheads plan indicates the monthly overhead rates to be applied to direct labor to determine the cost of goods sold. The plan gives a breakdown as to general and administrative costs, the cost of facilities, research

and development, etc. The monthly manpower and production plan indicates monthly output rates, the delivery of commercial and military aircraft on a monthly basis, direct (i.e. for production) labor requirements (numbers of personnel and their cost) on a monthly basis, and the projected monthly hiring/firing quotas. The subcontracting and procurement plan indicates subcontractors for government programs and details the firm's need for inputs other than labor on a monthly basis, along with the anticipated costs of these inputs.

The four plans just described form the division's annual operating plan, which is submitted to the headquarters planning staff after it has been approved by the division's management. As in the long term planning process, the headquarters planning staff may return the plan for modifications. Finally, after all divisional short term plans have been accepted, they are amalgamated into a corporate operating plan. Also incorporated into this plan is the annual operating plan for the corporate office. The corporate short term plan is submitted to top management for its review, and once this plan has been approved, the short term planning process ends.

At the conclusion of the short term planning process, the corporate planning cycle begins again. At the same time, a corporate review process begins, during which the just completed annual operating plan will be reviewed on a quarterly, or possibly on a semiannual, basis in light of actual operating results. The next section describes this review process. The remainder of this section looks more closely at certain important aspects of the short term planning process just described.

3. Short Term Planning: Government Sales, Contract Performance, and Cost Controls

Much of the short term planning associated with the sale of goods and services to the government can be based on the provisions of the contracts that were negotiated prior to the start of the short term planning process. In particular, for such items as military aircraft, government contracts generally specify product performance standards, a monthly delivery schedule, the price per plane (since, as pointed out in section B, production contracts are typically of the fixed price variety), the method by which the fee will be determined, etc. Such information proves helpful to the contractor during the preparation of the monthly manpower and production plan.

In addition, the government negotiates the overhead rates to be applied on all contracts,[185] and one of the by-products of this process is an estimate of reimbursable overhead costs. Under certain circumstances, such as those surrounding either an audit by the General Accounting Office or a general management review carried out by, or at the direction of, the administrative contracting officer, the government can issue specific directives to a contractor concerning its overheads.[186] Such information can prove helpful to the contractor when it formulates its monthly overhead plan.

Since contractor performance (or effort) weighs heavily in determining the fee to be earned,[187] the division must carefully plan the allocation of labor over government contracts

during the short term planning process. Where prices are fixed, as they are on most development contracts as well as on production contracts, control of costs is critical in order to prevent costs from rising and consuming part or all of the fee. Even under cost plus contracts, cost control is important, for even though costs now play a smaller role in determining the size of the fee, the contractor's productive efficiency, and in particular, improvements in productivity, are now included as a factor in determining the fee.[188]

A second important performance factor is the contractor's performance in meeting delivery schedules. Where the number of subcontractors and suppliers is large, the problem of trying to control the scheduling of production and delivery becomes more difficult. A subcontractor making a late delivery can cause the production schedule to slip, and this can lead to a late delivery, for which the prime contractor is likely to be penalized. Controlling subcontractor performance often necessitates placing teams of people, analogous to the government's plant representative offices, in the subcontractor's plants, and this in turn requires that manpower and dollars be allocated for that purpose.[189]

In short term planning connected with government sales, then, the emphasis is placed on allocating personnel and dollars so as to ensure satisfactory contract performance. In particular, short term planning for government sales emphasizes control of production and overhead costs and the control of production

rates in order to meet delivery schedules. Similarly, as the next subsection makes clear, short term planning for commercial sales also displays a decided cost and productivity emphasis.

4. Short Term Planning: Commercial Sales and Operating Efficiency

Short term planning for commercial sales is, in some important respects, more difficult than short term planning for government sales, although the basic thrust of the planning process is essentially the same. In each case short term planning is concerned with the employment levels of the variable inputs needed to satisfy the firm's production commitments. What tends to make commercial sales planning somewhat more difficult is the greater uncertainty concerning actual product demand. On the other hand, the difficulties associated with trying to predict resource requirements for research and development projects, which tend to complicate the task of government sales planning, generally have a smaller impact on the commercial side of the business. Overall, then, the relative difficulty of these two aspects of short term planning, and by implication, the relative amounts of time, manpower, and money that must be allocated to each aspect of short term planning, is largely dependent on the proportion of government sales made under research and development contracts.

In the case of commercial aircraft sales, the short term planning problem is more complicated than the one for military aircraft sales. While commercial aircraft are sold on a

contractual basis, the limited financial resources of the commercial airlines make contract cancellations or delivery postponements more likely than in the case of military aircraft sales.[190] A second problem associated with commercial aircraft sales concerns advance payments. If such payments are made at all on a commercial contract, they are generally much lower than progress payments made by the government under military contracts.[191] In addition, when the financial positions of commercial airlines worsen, they become loath to enter into long term contracts,[192] preferring instead to buy aircraft on much shorter notice once they have generated sufficient financial resources with which to make the purchase. Assuming the decision has been made (as part of the long term planning process) to continue production of the airplane or of some modified version, a decision concerning the production rate for the coming year must be made. This production rate must satisfy the constraint on the minimum feasible production rate, which is imposed by the technical conditions of production.

In contrast to the special planning problems associated with commerical aircraft sales, planning for the sales of other commerical products generally does not lead to problems any different from those faced by the airframe builders' non-aerospace commercial competitors. The main difference, in terms of planning, between these sales and sales of commercial aircraft is in inventory planning. In planning commercial

aircraft sales, production schedules are set to conform as closely as possible to the delivery schedule for firm orders so that inventories of completed aircraft can be held near zero. In planning for other commercial sales, for which inventories of finished goods are a normal part of doing business, one of the purposes of short term planning is to determine the appropriate (in light of demand and cost considerations) inventory levels.

Overall, the short term planning process is designed to achieve operating efficiency in the area of commercial sales. As was the case with government sales, short term planning of commercial operations focuses on variable inputs such as the labor used in the production process and seeks to determine employment levels consistent with cost minimization.

5. Summary

The short term planning process is concerned mainly with the allocation of variable inputs among existing and about-to-be-introduced product lines and with the efficient use of the firm's existing capital resources, in contrast to the long term planning process, which is mainly concerned with the acquisition or disposal of capital resources, the winning of new government contracts, and the development of new commercial lines of business. Because the short term planning process begins once the long term planning process has been completed and uses the long term plan as a planning base, short term planning normally requires just one quarter, as opposed to the two quarters usually required for

long term planning. Using the long term plan as a basis for the short term plan also ensures consistency between the two plans.

One of the important outputs of the short term planning process is a set of provisional quarterly financial statements for the corporation. That is, once top management has approved the corporate operating plan submitted by the headquarters planning staff (see Figure 7), a provisional profit and loss statement and a provisional balance sheet can be prepared for each quarter - or for each month, if so desired - of the corporate fiscal year. These provisional financial statements are used by top management during the fiscal year to check the progress of the corporation toward its long term and short term financial goals and objectives.

While the completion of the corporate operating plan and the preparation of the provisional corporate financial statements mark the end of the corporate planning cycle, there remains a very important follow-on to the corporate planning cycle, namely, the corporate review(s). The next section describes the corporate review process, the purpose of which is to measure periodically the performance of the divisions against the respective divisional plans and to modify the divisional and corporate operating plans in light of operating experience.

G. THE CORPORATE REVIEW PROCESS

Though substantial resources are devoted to formulating the corporate and divisional plans, the uncertainties associated

with estimates of product demand, input costs and availabilities, etc., in the future, as well as unforeseen circumstances, such as an oil embargo, an unexpected sharp decline in the demand for airline passenger travel, or an unanticipated contract termination, will cause actual performance to deviate from the projections outlined in the corporate and divisional operating plans. Thus, it has been deemed necessary by the managements of the major airframe builders to conduct formal periodic reviews - normally on a quarterly basis, though in some cases, on a semi-annual basis - to measure these deviations, and if possible, to determine their cause so that the divisional and corporate operating plans for the remainder of the fiscal year can be adjusted in accordance with the firm's operating experience.

The existence of the review process is indicative of the fact that the corporate planning and review process, when considered as a whole, is an adaptive process. That is, the planning and review process exhibits feedback control in that each periodic corporate review causes information on divisional performance to be generated that is used by top management and divisional managers to modify their operating plans. In addition, the corporate reviews enable top management and the headquarters planning staff to reevaluate periodically the operating environment and performance of each division. The information collected and the evaluations performed as part of the corporate reviews for the third and fourth quarters of the fiscal year are, to the extent that they enable corporate planners to evaluate the current state

of demand in each of the firm's product markets, helpful to the headquarters planning staff at the time it prepares the environmental forecast.

Figure 8 shows the corporate planning and review cycle for arbitrary year T. The whole cycle spans a period approximately nine quarters in length. The planning for year T takes place the previous year. The corporate review for each quarter takes place soon after the end of the quarter, with the time lag determined by how much time is required to collect and process the data needed to carry out the review. The fourth quarter review is different from the three earlier reviews in that, not only can the full year's performance be measured against the whole operating plan, but also the review of the year's performance forms the basis for the annual report to the firm's shareholders.

Each quarterly review contains the following basic elements. First, the actual results - sales by product line, levels of resource usage, net operating income for the division, etc. - are summarized for both the quarter and the year to date. The actuals are compared with the approved operating plan. Usually this is done simply by listing the actual figure next to the projection - and significant variations are noted. Second, based on the actuals to date, an up-to-date forecast for the balance of the fiscal year is presented, along with a statement of any changes that may have been made in the underlying assumptions since the operating plan was approved. Third, the status of major military

Qtr I	Qtr II	Qtr III	Qtr IV	Qtr I	Qtr II	Qtr III	Qtr IV	Qtr I
Yr T-1	Yr T-1	Yr T-1	Yr T-1	Yr T	Yr T	Yr T	Yr T	Yr T + 1
environ. forecast	long range plan Year T and beyond		Year T operating plan		Qtr I Year T review	Qtr II first half Year T reviews	Qtr III three-qtrs Year T reviews	Qtr IV full year Year T reviews

Figure 8: The Corporate Planning and Review Cycle

and commercial programs is reviewed, with special emphasis placed on problems - existing or potential - that might in the future require the attention of top management,[193] e.g. those problems that might call for large expenditures or major schedule changes and that could affect other divisions of the company. Fourth, the status of capital expenditure programs and any cost or schedule changes to them are reviewed. Fifth, research and development activities, their cost, and significant accomplishments are reviewed. Sixth, efforts directed toward winning new military programs that are near to bidding are reviewed. For each of the above elements of the review process, top management reviews the record to date and suggests appropriate modifications of strategies, expenditure levels, etc. In particular, one or more of the divisional operating plans may be changed at the direction of top management in light of that division's performance to date.

The corporate review process, then, is a device that enables top management to review periodically the performance of the corporation's operating divisions and to determine what changes need to be made, in light of each division's experience to date, to each division's operating plan in order to improve the likelihood that by the end of the fiscal year the corporation's goals and objectives for the year will have been met.

H. SUMMARY AND CONCLUSIONS

The nine major military airframe builders in the United States are large diversified organizations whose performance

is influenced to a significant degree by variations in the size and number of major military aircraft programs. The business environment within which these firms operate is characterized by several different types of risk, some of which arise out of their special relationship with their main customer, the U.S. government, and some of which are peculiar to the highly technical and specialized nature of their aerospace business. In addition, the apparent decline in the number of major military aircraft programs, the stagnant demand for commercial passenger jet aircraft, and the increasing foreign competition from firms financed by their governments, have limited the opportunities for growth in these firms' traditional markets, and more importantly, have threatened the structure of the industry.

Due in part to the nature of the aerospace business and in part to their dependence on the sale of high technology aircraft to the government, these firms have had to evolve a long term planning process capable of coping with the risks they face. These firms must plan their allocation of human capital on the basis of very limited information, knowing that the penalty for guessing incorrectly may include the failure to win a major program. They must allocate research expenditures so as to develop the technology that will be needed by weapons systems that may not reach the development stage for a decade or more. Thoughout the research and development process they must compete with one another for the favor of their main customer, the U.S. government, and for the relatively more

lucrative production contracts that secure for each of their recipients a place among the select group of prime government contractors.

Their commercial business, particularly if it includes the sale of commercial passenger aircraft, can also entail substantial risks. The number of potential customers is greater, but the financial strength of each is not only weaker than the government's, but also susceptible to the swings of the business cycle. Since the cost of developing a new generation of commercial aircraft may exceed the developing company's net worth, the risk of ultimate financial failure cannot be ignored. Moreover, in recent years a severe recession and an increase in foreign competition have intensified these risks.

The substantial risks attendant upon their aerospace operations and the limited growth opportunities provided by the markets for commercial and military aircraft have caused many of the major airframe builders to look outside the industry for opportunities to diversify and grow. But the limited alternative uses to which their fixed capital can be put and the nature of their aerospace business - the production and marketing of highly sophisticated products to a relatively small number of commercial and government buyers - have forced these firms to be very selective with regard to how they choose to diversify.

Similarly, the nature of the aerospace business and the dependence of these firms on sales of aircraft to the government give rise to special problems in short term planning. Due to

the high costs of temporarily shutting down a production line or of maintaining an inventory of completed aircraft, production schedules must be set to conform as closely as possible to anticipated delivery schedules. Due to the importance of meeting the specifications of government production contracts, most of which are granted on a fixed price basis, it is necessary that production schedules and production and overhead costs be carefully controlled.

All the factors mentioned above combine to make the typical airframe builder's task of planning a difficult one, the requirements of which are, in the opinion of this writer, more demanding than those faced by the majority of non-aerospace firms. This paper has described how the major airframe builders conduct their long term and short term planning. The discussion has highlighted the important aspects of each process and has indicated the relationship between the two. The paper has also drawn attention to the important differences between doing business with the government and doing business with commercial customers and has pointed out the implications of these differences for the long term and short term planning processes of the nine major military airframe builders.

It is the author's intention to develop an analytical model of the planning cycle described in this paper and to use the model to study the long term and short term planning processes of the major military airframe builders, and in particular, to study how certain specified changes in government procurement

policies are likely to affect these firms and how the risks discussed in section B affect not only the observed behavior of these firms, but also the way they conduct their planning. The results of that study will be reported in a later technical report.

FOOTNOTES

1. This paper is based in part on personal interviews conducted at The Boeing Company, Fairchild Republic Company (a division of Fairchild Industries, Inc.), the Convair Division of General Dynamics Corporation, Grumman Corporation, Vought Corporation (formally LTV Aerospace Corporation and a wholly owned subsidiary of the LTV Corporation), Lockheed Aircraft Corporation, McDonnell Douglas Corporation, Northrop Corporation, and Rockwell International Corporation. The author would like to thank the executives with whom he spoke for their generous assistance, though he alone accepts full responsibility for any errors that may have been committed in describing these firms' planning processes. This paper is also included as Chapter Six in the author's forthcoming doctoral dissertation.

2. The term 'airframe' refers to the body of the airplane without its engines. For the information of the reader, the two major producers of engines that are installed in the airframes produced by the firms listed in footnote 1 are United Technologies Corp. (through its Pratt & Whitney Aircraft Div.) and General Electric Co.

3. See "A shakeout for U.S. fighter-plane makers," Business Week (June 9, 1975), and "General Dynamics: Winning in the Aerospace Game," Business Week (May 3, 1976). According to these articles, the threatened firms are Fairchild, Grumman, and Vought (LTV). However, Joseph G. Gavin, Jr., President of Grumman Corp., has stated publicly that he expects follow-on orders to carry F-14 production beyond the currently projected 1980 termination date. See "The New Face of the Defense Industry," Business Week (January 10, 1977), p. 55. A recent study conducted jointly by the Department of Defense and the Office of Management and Budget concludes, however, that there is excess capacity in the aircraft industry costing the Department of Defense approximately $400 million per year to maintain and recommends that the industry be consolidated. See "Washington Roundup," Aviation Week & Space Technology (January 24, 1977), p. 11.

4. See "Conferees Vote Money for the B1 Bomber And for Nuclear-Powered 'Strike' Cruiser," Wall Street Journal (July 28, 1975); "B1 Decision Is Delayed by Senate Panel In Passing Defense Appropriations Bill," Wall Street Journal (July 22, 1976); and "Conferees Vote to Put B1 Bomber Funds On Tight Rein Until After Inauguration," Wall Street Journal (September 1, 1976).

5. See "Early Revival Unlikely As Jumbo-Plane Sales Continue to Languish," Wall Street Journal (August 10, 1976), and "Aerospace and Defense," Forbes (January 1, 1977), p.136. There are some signs, however, that the demand for commercial aircraft, and in particular, the Boeing 727, is beginning to pick up. Revised noise standards and the need for replacement aircraft are at least partly responsible. See "Airlines give Boeing a one-shot boom," Business Week (October 11, 1976). The long term outlook is also brightening, though many airlines will require a period of sustained profitability if they are to be able to satisfy their need for new aircraft. See "Billions and billions and billions to grab for," The Economist (September 11, 1976); "Time To Fasten Seat Belts?," Forbes (October 15, 1976); and "Nation's Airlines Face A Key Problem: How To Pay for New Airplanes," Wall Street Journal (October 22, 1976).

6. See "Lockheed Woes Increase as Plan For Rescue Fails," Wall Street Journal (March 3, 1975), and "Biting the bullet on the TriStar," Business Week (April 12, 1976). However, indications are that the patient is on the mend. See "The Fabulous Invalid," Forbes (August 15, 1976), and "Lockheed Restructuring Voted by Owners Of Common; Debt-Holder Approval Seen," Wall Street Journal (September 30, 1976).

7. See The New Face of the Defense Industry, op.cit., and also Aerospace and Defense, op.cit.

8. That is, 'total package procurement', in which companies were forced to accept a single fixed price contract covering both development and production, is no longer part of the Department of Defense's procurement policy. The current DOD policy regarding major system acquisitions is outlined in Department of Defense Directive 5000.1, "Major System Acquisitions" (January 18, 1977) and in Department of Defense Directive 5000.2, "Major System Acquisition Process" (January 18, 1977).

9. And, in at least one case, in accordance with the wishes of the firm's debt-holders. See footnote 6.

10. K.G. Harr, Jr., "A Short Course in Aerospace Economics 1976," Aerospace (September 1976), p. 11.

11. Ridder and Heinz classify 634 firms as belonging to the aerospace industry based on the industry classifications provided by Dun and Bradstreet's Million Dollar Directory, Standard and Poor's Register of Corporations, and several other

sources. See W.C. Ridder and M.K. Heinz, "Structure, Conduct, and Performance of the United States Aerospace Industry," unpublished M.S. thesis (Naval Postgraduate School; Monterey, California; March 1976). Ridder and Heinz provide an interesting historical perspective on the industry as well as a careful analysis of the industry's structure, conduct, and performance. An earlier study of the aerospace industry that carefully examined the major airframe builders is H.O. Stekler, The Structure and Performance of the Aerospace Industry (University of California Press; Berkley; 1965). After allowing for mergers and after excluding Martin Marietta, which no longer builds aircraft, Stekler's list of the major airframe builders is identical to the list of firms in footnote 1. Ibid., p. 47. A second study by Carroll considers these firms as well as the missile frame builders. S.L. Carroll, "The Airframe Industry," unpublished Ph.D. dissertation (Harvard University; Cambridge, Mass.; August 1970).

12. Harr, op.cit., p. 12

13. Ibid., p. 12.

14. Ibid., p. 12.

15. Ibid., p. 11.

16. Strictly speaking, LTV is not an aerospace firm. Because aerospace sales constitute approximately 12 percent of total sales (see Table 3 below), whereas steel operations contribute 39 percent and meat and food products contribute 48 percent, as reported in the company's Form 10-K for its fiscal year 1975, the company is usually classified as a 'conglomerate', rather than as a member of any single industry (for example, see "Multicompanies," Forbes (January 1, 1977), p. 101). The firm does, however, participate in the industry through its Vought Corp. subsidiary, and if the significance to LTV of this participation were to be judged in terms of profits, rather than sales, then, in 1975 at least, aerospace production would become preeminent (see Table 6 below).

17. These firms also play very important roles in the international market for commercial aircraft. The Aerospace Industries Association of America estimates that roughly four of every five planes flown commercially world-wide are American-made. Harr, op.cit., p. 7

18. Ibid., p. 7.

19. See, for example, "Cruise Missile's Future Is Mainly Up to Carter; Its Potential Is Great," Wall Street Journal (January 3, 1977), and "Defense Budget of $110.1 Billion Proposes Big Weapons Rise With Little Fat to Cut," Wall Street Journal (January 18, 1977).

20. These factors, and their impact on the defense industry, are discussed in M.L. Weidenbaum, The Economics of Peacetime Defense (Praeger; New York; 1974).

21. Since 1968 total employment within the aerospace industry has fallen by more than one-third. Moreover, between 1968 and 1975 more than 70,000 highly skilled jobs - scientists, engineers, and technicians - were lost. Harr, op.cit., p. 12.

22. For example, in the Fortune 500 ranking for 1970, Boeing was ranked 17, Lockheed was ranked 33, and McDonnell Douglas was ranked 44. See "The Fortune Directory of the 500 Largest Industrial Corporations," Fortune (May 1971).

23. One added indication of this is the fact that, if Vought Corp. were ranked separately from the rest of LTV, it would rank number 330 in the FORTUNE 500.

24. Six of the top 10 are airframe builders. Of the remaining four top 10 DOD contractors, United Technologies Corp. (no. 3), through its Pratt & Whitney Aircraft Division, has contracts to build engines for three of the four new fighters; General Electric Co. (no. 7) has the engine contract for the F-18; and Litton Industries Inc. (no. 8) and Hughes Aircraft Co. (no. 9) are also important suppliers of aerospace products, See Ridder and Heinz, op.cit., Appendix J, p. 400.

25. Harr, op.cit., p. 11.

26. Ibid., p. 12.

27. It will be argued below that it is human capital - in the form of the knowledge and experience embodied in skilled engineers and scientists - rather than physical capital - in the form of plant and equipment, some of which is owned by the government - that is the scarcer of the two components of the firm's total capital resources and that is, consequently, of greater concern to each firm's strategic planners who must plan the allocation of these capital resources.

28. _Ibid._, p. 14.

29. D.E. Raphael of the Stanford Research Institute believes that the aerospace industry faces an impending widespread capital shortage, and he estimates that the working capital requirements of these firms will rise from $5.9 billion in 1975 to $8.8 billion in 1980 and to $15 billion in 1985. D.E. Raphael quoted in _The New Face of the Defense Industry_, _op.cit._, p. 53.

30. _Ibid._, p. 52, and Department of Defense, _Defense Procurement Circular Number 76-3_ (Washington, D.C.; September 1, 1976), p. 12.

31. Comparative figures are provided in "Where Private Industry Puts Its Research Money," _Business Week_ (June 28, 1976).

32. _Ibid._, p. 65. Even though DOD funds a large proportion of defense-related research, it does not finance 100 percent of the research, and on a project-by-project basis each of the airframe builders is risking large sums of money. For example, Boeing Co. spent $41 million of its own money, in addition to $95.2 million supplied by DOD, for research and development connected with the YC-14, the new short take-off-and-landing transport being developed for the Air Force (in competition with McDonnell Douglas's YC-15). _Ibid._, p. 66.

33. The references that set out current DOD policy regarding major weapons system acquisition are given in footnote 8.

34. The implications of the type of contract for risk-sharing between the government and the contractor are discussed below in subsection 6.

35. One aerospace executive told the author that his company estimated that approximately 56 percent of IR&D funds were spent on projects that would never result in fruitful military applications, and that, of the remainder, only one quarter (i.e. 11 percent of the total) would be spent on developing weapons systems that his company would produce (the other three quarters being spent on projects that would lose out to other firms).

36. One of the earliest articles on the subject was T.P. Wright, "Factors Affecting the Cost of Airplanes," _Journal of the Aeronautical Sciences_ (vol. 3; no. 4; February 1936), pp. 122-128. See also K. Hartley, "The Learning Curve and Its Application to the Aircraft Industry," _Journal of Industrial Economics_ (vol. 13; no. 2; March 1965), pp. 122-128. The

existence of the learning curve has been taken into account in production and cost planning by military, as well as by industry, planners. For a survey of Air Force applications see H. Asher, "Cost-Quantity Relationships in the Airframe Industry," R-291 (The RAND Corporation; Santa Monica, CA; 1956). It should be noted that the learning curve phenomenon is not unique to the airframe industry. For other industries in which it applies see W.Z. Hirsch, "Firm Progress Ratios," Econometrica (vol 24; no. 2; April 1956) pp. 136-143. In addition, the phenomenon of the learning curve also has applications at the macroeconomic level. See P.J. Verdoorn, "Complementarity and Long-Range Projections," Econometrica (vol 24; no. 4; October 1956), pp. 429-450, and K.J. Arrow, "The Economic Implications of Learning by Doing," Review of Economic Studies (vol. 29; 1962), pp. 155-173.

37. An interesting general discussion of learning curves is provided in S.C. Webb, Managerial Economics (Houghton Mifflin; Boston; 1976), ch. 17.

38. Hartley, op.cit., p. 122, and Webb, op.cit., p. 251.

39. The equation of the learning curve in Figure 1 is

$$\ell = 8000\, x^{-0.32193},$$

where ℓ is the direct labor input per airframe and x is the cumulative number of airframes produced. More generally, a learning curve satisfies an equation of the form

$$\ell = ax^{b},$$

where a is the direct labor input of the first airframe produced and $b = \log_2 p$, where p is the percent of learning expressed as a decimal and where $\log_2$ signifies a logarithm to the base 2. Note that the shape of the learning curve implies that the learning process is subject to steadily diminishing returns.

40. Though inflation might cause the cost per airframe measured in current dollars to increase - if rising unit input costs more than offset the effect of improved labor efficiency - the cost per airframe would still fall when measured in term of dollars of constant purchasing power (i.e. in real terms).

41. In essence, the controversy surrounding the Navy's decision to procure the F-18 despite congressional pressure to procure the F-17, which was a modification of the F-16 selected previously by the Air Force, was the result of this sort of disagreement as to whether the additional costs incurred in selecting a different design could be justified on the grounds of improved effectiveness.

42. The actual point beyond which a major program becomes virtually nontransferable probably lies somewhere before the award of the first production contract, but after the selection of the winner of the prototype competition. That is, during the final development and the test and evaluation stages of the program, the firm that won the prototype competition develops the finished product. Since the technology developed and the experience accumulated during these stages cannot be transferred costlessly, at some point the potential costs of transferring the program become so high as to in effect preclude a change of prime contractor.

43. That is, a market for a product characterized by a single buyer (the Department of Defense through one of its services) and a single seller (the contractor). Bilateral monopoly is discussed in most elementary price theory textbooks. For example, see R. Sherman, The Economics of Industry (Little, Brown and Company; Boston; 1974), pp. 283-287.

44. See "Lockheed Sets L-1011 Charge Of $515 Million," Wall Street Journal (March 31, 1976).

45. The current competition between Boeing and McDonnell Douglas for a contract worth approximately $2 billion to build midair refueling tankers is an example. The Boeing entry will utilize the 747 airframe, while the McDonnell Douglas entry will utilize the DC 10 airframe. (The Lockheed entry - a derivative of the L-1011 - has already been eliminated.) Aerospace and Defense, op.cit., p. 136.

46. Harr, op.cit., p. 7.

47. This latter figure was computed by treating Vought Corp. as if it were an aerospace firm separate from LTV Corp.

48. This procedure has a strong impact on Northrop Corp.'s government sales. If sales to foreign governments were included among 'government sales', then the share of government sales in Northrop Corp.'s total sales would exceed 80 percent. The main reason for this large difference is that the primary market for Northrop Corp.'s F-5 fighter is foreign governments.

49. See footnotes 21 and 22.

50. For example, sales of the A-10 aircraft formed 23% of Fairchild Industries's total sales during 1975. Fairchild Industries Form 10-K, op.cit., p. 6.

51. Defense Procurement Circular No. 76-3, op.cit. The DOD's primary motive was to encourage defense contractors to increase their investment in plant and cost-saving new equipment. The Profit '76 study recommended four major changes designed to accomplish this. First, interest, including the imputed interest on contractor-owned facilities, became an allowable cost. Second, the contractor's level of investment in facilities was introduced as a factor into the weighted guidelines that government contracting officers must follow in negotiating a profit objective with the contractor. Third, risk will be weighed more heavily and cost will be weighed less heavily in negotiating profit levels. Fourth, productivity improvements were introduced into, and past contractor performance was deleted from, the list of guidlines used to determine profit levels. It should be noted that the policy changes will be less favorable to the airframe builders than they will be to shipbuilders and other government contractors, according to Brig. General James W. Stansberry, USAF, Director, Profit '76, quoted in "Pentagon Drafts Policy to Spur Spending By Defense Contractors on New Facilities," Wall Street Journal (July 6, 1976).

52. Ibid., pp. 12-15; Aerospace Industries Association of America, Risk Elements in Government Contracting (Washington, D.C.; October 1970), pp. 6-9; Aerospace Profits vs. Risks (Washington, D.C.; June 1971), ch. 4; and J.R. Fox, Arming America: How the U.S. Buys Weapons (Division of Research, Harvard Business School; Boston; 1974), pp.236-240.

53. The argument that risks are high and returns are low in the aerospace industry in relation to other industries is made in Harr, op.cit., p. 12, and in J.K. Brown and G.S. Stothoff, The Defense Industry: Some Perspectives from the Financial Community, (Division of Management Research, The Conference Board; New York; 1976). The opposite view is expressed in Weidenbaum, op.cit., pp. 69-70, which cites a GAO study of aerospace profitability over the period 1966-1969, and in The New Face of the Defense Industry, op.cit., p. 56. For a discussion of these articles see the next footnote.

54. One of the practical problems encountered in analyzing the question of the sufficiency of the returns earned by aerospace firms is the period of time covered by the analysis. The years 1966-1969 covered by the GAO study referred to in footnote 53 preceded the post-Vietnam slump in defense spending, and much of the empirical evidence cited in the Business Week article ("The New Face of the Defense Industry") is based on the same period. In this regard the Brown and Stothoff study, which focuses on the period 1965-1974, reports statistical results that are less biased.

55. For example, Risk Elements in Government Contracting, op.cit.

56. Profit '76 Summary Report (U.S. Government Printing Office; Washington, D.C.; December 7, 1976.)

57. The apparent preference of contractors for investing in facilities to be used in commercial production, rather than to support government production, was the major justification for the Profit '76 study. Defense Procurement Circular No. 76-3, op.cit., p. i.

58. An overview of the procurement process is provided in S.J. Evans, H.J. Margulis, and H.B. Yoshpe, Procurement (Industrial College of the Armed Forces; Washington, D.C.; 1968). Several excellent analyses of the weapons acquisition process have been performed. The classic studies are M.J. Peck and F.M. Scherer, The Weapons Acquisition Process: An Economic Analysis (Division of Research, Harvard Business School; Boston; 1962), and F.M. Scherer, The Weapons Acquisition Process: Economic Incentives, (Division of Research, Harvard Business School, Boston; 1964). An interesting follow-on of these studies is Fox, op.cit. An interesting discussion of the differences between government-contractor transactions and commercial transactions can be found in J.F. Gorgol, The Military-Industrial Firm (Prager; New York; 1972), ch. 2.

59. See Peck and Scherer, op.cit., ch. 3, and J.M. Suarez, "Profits and Performance of Aerospace Defense Contractors," Journal of Economic Issues (vol. 10; no. 2; June 1976), pp. 386-402, for more on the non-market character of the weapons acquisition process.

60. It should be noted, however, that prior to World War II this commercial-like process was heavily relied on to generate new ideas for military aircraft. Ibid., ch. 4.

61. See Aerospace Industries Association of America, Monopsony: A Fundamental Problem in Government Procurement (Washington, D.C.; May 1973) and Stanford Research Institute, "The Industry-Government Aerospace Relationship," two volumes (Menlo Park, CA; May 1963).

62. See Fox, op.cit., pp. 256-257, 467-471. An interesting theoretical discussion of the bidding process can be found in D.P. Baron, "Incentive Contracts and Competitive Bidding," American Economic Review (vol. 62; no. 3; June 1972), pp. 384-394; C.C. Blaydon and P.W. Marshall, "Incentive Contracts and Competitive Bidding: Comment," American Economic Review (vol. 64; no. 6; December 1974), pp. 1070-1071; and D.P. Baron, "Incentive Contracts and Competitive Bidding: Reply," American Economic Review (vol 64; no. 6; December 1974), pp. 1072-1073.

63. Harr, op.cit., p. 13.

64. Due to the abandonment of 'total package procurement' this latter risk has been reduced substantially in recent years. See The New Face of the Defense Industry, op.cit., p. 52, and footnote 8.

65. See footnote 42.

66. See the references listed in footnote 38.

67. See A.M. Agapos and L.E. Gallaway, "Defense Profits and the Renegotiation Board in the Aerospace Industry," Journal of Political Economy (vol. 78; no. 5; September/October 1970), pp. 1093-1105; Weidenbaum, op.cit., pp. 70-72; and J.F. Weston, ed., Procurement and Profit Renegotiation (Wadsworth; San Francisco; 1966).

68. Weidenbaum, op.cit., p. 72.

69. The six factors are the following: the efficiency of the contractor, the reasonableness of cost and profits, the amount and source of public and private capital employed, the extent of risk assumed, the nature and the extent of the contribution to the defense effort, and the character of the business. Ibid., p. 71.

70. Ibid., p. 72, and Harr, op.cit., p. 13.

71. Weidenbaum, op.cit., p. 72. Weidenbaum argues that the board's preoccupation with profits rather than costs is not in the taxpayer's best interests since cost levels and cost overruns are so much greater in magnitude than profits. He argues that the board should pay greater attention to the reasonableness of contractor costs.

72. C. Kaysen, "Improving the Efficiency of Military Research and Development," in E. Mansfield, ed., Defense, Science, and Public Policy (W.W. Norton; New York; 1968), p. 119. See also Harr, op.cit., p. 13, and Weidenbaum, op.cit., p. 70.

73. See, for example, J. Hirshleifer, Investment, Interest, and Capital (Prentice-Hall; Englewood Cliffs, N.J.; 1970), p. 215; Aerospace Profits vs. Risks, op.cit., p. 2; and D. Vickers, The Theory of the Firm: Production, Capital, and Finance (McGraw-Hill; New York; 1968), p. 7.

74. F.H. Knight, Risk, Uncertainty and Profit (Houghton Mifflin; New York; 1921).

75. G.C. Philippatos, Financial Management Theory and Techniques (Holden-Day; San Francisco; 1971), pp. 69-70.

76. Ibid., p. 70, and J.C. Van Horne, Financial Management and Policy, 2nd ed. (Prentice-Hall; Englewood Cliffs, N.J.; 1971), pp. 46, 198-200.

77. See, for example, Risk Elements in Government Contracting, op.cit.

78. As, for example, the Profit '76 Study. See footnote 56 for reference.

79. Aerospace Profits vs. Risks, op.cit., pp. 2-4.

80. These measures are the ones suggested by Van Horne. See footnote 76 for page references.

81. J.R. Kurth, "Why We Buy the Weapons We Do," Foreign Policy (no. 11; summer 1973), pp. 43-46, or J.R. Kurth, "Aerospace Production Lines and American Defense Spending," in S. Rosen, ed., Testing the Theory of the Military-Industrial Complex (D.C. Heath; Lexington, Mass.; 1973), pp. 142-144.

82. For a view of the weapons procurement process contrary to Kurth's see A. Kanter and S.J. Thorson, "The Weapons Procurement Process: Choosing Among Competing Theories," in Rosen, op.cit., pp. 157-196.

83. Fairchild Industries, Inc., 1975 Annual Report (Fairchild Industries, Inc; Germantown, MD.), p. 3.

84. Aerospace Profits vs. Risks, op.cit., p. 2, makes the same point, although it adopts 'the probability of obtaining profits substantially below a competitive average' as the definition of financial risk and suggests 'a firm's dispersion (as measured by standard deviation, coefficient of variation, or skewness) in the rate of return from its trended mean' as the best statistical measure of overall risk. Ibid., p. 10. The Profit '76 study chose the standard deviation of the firm's rate of return from its mean over a ten-year period as its measure of the firm's financial risk. See footnote 56 for a reference.

85. These might also be called research and development risks. Ibid., pp. 2-3. See also Harr, op.cit., p. 13. For a practical example of these risks see "A plague of faulty fighter engines," Business Week (August 25, 1975), and "Grumman Confirms Engine Problems Of F14 Navy Plane," Wall Street Journal (May 21, 1976).

86. See Aerospace Profits vs. Risks, op.cit., pp. 2-3. In particular, the failure to make the required advance in one area, for example, designing a radar system of the required size and weight, may necessitate design changes in other parts of the system, for example, redesigning other aircraft components to make them smaller and lighter to compensate for the excessive size and weight of the radar system.

87. Ibid., p. 2.

88. Defense Procurement Circular No. 76-3, op.cit., p. 12.

89. Over time the impact of this source of risk may be dulled by what Kurth calls the 'follow-on imperative': about the time one major government contract phases out another one phases in. See Kurth, Why We Buy the Weapons We Do, op.cit., pp. 38-42, or Kurth, Aerospace Production Lines and American Defense Spending, op.cit., pp. 139-142, for supporting evidence. The reference provided in footnote 82 takes a position contrary to Kurth's. However, the observed pattern of follow-on awards may not, in the opinion of this writer, be the result of government policy designed to help prospective have-nots, but rather, may simply reflect the significant advantages - such as grasp of related technology, trained labor force, available production facilities, etc. - a contractor has in bidding on follow-on contracts.

90. See Sherman, op.cit., pp. 153-154.

91. Defense Procurement Circular No. 76-3, op.cit., pp. 12-15.

92. Ibid., p. 14.

93. The twin problems of incurring greater overall cost risk through subcontracting, while at the same time shifting cost risk onto subcontractors, become somewhat greater when work is subcontracted on an international basis, as it has been on the F-16.

94. Business Week estimates that overcapacity in the U.S. aerospace industry as of January 1977 might have been as high as 40%. The New Face of the Defense Industry, op.cit., p. 58. The impact of such overcapacity is partly mitigated by the fact that much of the overcapacity is in government-owned plants. Ibid., p. 58. See also Aerospace Profits vs. Risks, op.cit., pp. 5-7.

95. Harr, op.cit., p. 13, and Aerospace Profits vs. Risks, op.cit., p. 5.

96. See General Dynamics: Winning in the Aerospace Game, op.cit., and A shakeout for U.S. fighter-plane makers, op.cit.

97. See N. Rosenberg "On technological expectations," Economic Journal (vol. 86; no. 343; September 1976), pp. 523-535. Introducing an airplane 'too soon' would give competitors an opportunity to observe market demand and to modify their aircraft to suit better the needs of potential buyers, while introducing it 'too late' would let the competitors capture a dominant position in the market place. Exactly this sort of problem confronts Boeing and McDonnell Douglas and their decisions as to when to introduce the next generation of commercial jet aircraft. See "The Next Commercial Jet . . . If," Business Week (April 12, 1976).

98. As, for example, Northrop's and McDonnell Douglas's joint venture on the F-18. Joint commercial ventures across international boundaries are also likely. See "I'm McDonnell Dassault, buy me," The Economist (August 21, 1976), and "Free-world partners plan jets for the 1980s", Business Week, (August 30, 1976).

99. In the case of the McDonnell Douglas - Northrop joint venture, each will act as a prime contractor on a different version of the same basic aircraft - McDonnell Douglas on the U.S. Navy version and Northrop on the land-based foreign version of the F-18. See A shakeout for U.S. fighter-plane makers, op.cit., and The New Face of the Defense Industry, op.cit.

100. This was made clear to the author in the course of interviews with executives of the nine firms listed in footnote 1, and in particular, during his interview with Joseph G. Gavin, Jr., President of Grumman Corp.

101. Government-furnished fixed capital accounts for less than 20 percent of the aerospace industry's total fixed capital. Aerospace Profits vs. Risks, op.cit., pp. 5-6.

102. This is one of the intentions of the Profit '76 study's recommendations, namely, to get defense contractors to purchase their own plant and equipment. The New Face of the Defense Industry, op.cit., p. 56.

103. Working capital requirements, expressed per dollar of sales, are higher in the aerospace industry than in other durable goods industries because of the long lead times for development and the high cost of skilled engineering and technical talent. The government funds at least one-half of the aerospace industry's working capital requirements. Aerospace Profits vs. Risks, op.cit., pp. 5-6.

104. The desirability of government-furnished capital is a question debated among the military airframe builders. On the one hand, Northrop believes that contractors should own all their own facilities and bear all the financial and business risks - even to the extent of doing development work under fixed-price contracts - and receive greater profits accordingly, while on the other hand, Grumman believes that DOD should provide a large portion of the capital and shoulder a large share of the risks, particularly those associated with research and development. The New Face of the Defense Industry, op.cit., p. 58. Based on personal interviews, this writer's conclusion is that the Grumman viewpoint is shared by most, but not all, of the other major military airframe builders.

105. See Aerospace Profits vs. Risks, op.cit., pp. 10-11; Risk Elements in Government Contracting, op.cit., ch. 1; and F.T. Moore, "Incentive Contracts," in S. Enke, ed., Defense Management (Prentice-Hall; Englewood Cliffs, N.J.; 1967), ch. 12.

106. Ibid., ch. 12; O.W. Williamson, "The Economics of Defense Contracting: Incentives and Performance," in R.N. McKean,ed., Issues in Defense Economics (Columbia University Press; New York; 1967), pp. 217-256; F.M. Scherer, "The Theory of Contractual Incentives for Cost Reduction," Quarterly Journal of Economics (vol. 78; no. 2; May 1964, pp. 257-280; J.J. McCall, "The Simple Economics of Incentive Contracting," American Economic Review (vol. 60; no. 5; December 1970), pp. 837-846; and M.E. Canes, "The Simple Economics of Incentive Contracting: Note," American Economic Review (vol. 65; no. 3; June 1975), pp. 478-483. The Scherer paper is particularly noteworthy because it offers empirical evidence in support of the hypothesis that defense contractors are risk averse. Scherer, The Theory of Contractual Incentives for Cost Reduction, op.cit., pp. 273-276.

107. These basic contract types, as well as several variations, are discussed in Evans, Margulis, and Yoshpe, op.cit.

108. Defense Procurement Circular No. 76-3, op.cit., pp. 12-15. See also Aerospace Profits vs. Risks, op.cit., p. 10.

109. An extreme case in which virtually all risk was borne by the contractor was the 'total package procurement' policy introduced by Robert McNamara when he was Secretary of Defense. Under total package procurement, companies were forced to bid on a fixed-price contract covering both development and production, and, as Lockheed's experience on the C-5A transport contract and Grumman's experience on the F-14 contract attest, the contractor's risk of severe financial loss due to such factors as inflation and unforseen costs were intolerably high, and as a result, total package procurement has been

abandoned in favor of separate contracts for development and production, with the former normally on a cost-plus basis and with the latter normally on a FPI basis for the early stages of production. Defense Procurement Circular No. 76-3, op.cit., p. 12.

110. Ibid., p. 11

111. Ibid., p. 11, and Risk Elements in Government Contracting, op.cit., ch. 2.

112. For example, Fairchild Industries's attempts to develop its communications business (see "A Last Run For The Money," Forbes (May 15, 1976)) and Rockwell International's acquisition of Admiral Corp. and many other commercially oriented companies (see "Rockwell walks a rough road to profits," Business Week (November 3, 1975) and "Rockwell's surprising winner: Collins Radio," Business Week (November 15, 1976)). In addition, General Dynamics recently announced its intention to look for potential non-aerospace commercial acquisitions (see "General Dynamics Sees Bright Future On Strength of Tanker, Fighter Projects," Wall Street Journal (January 27, 1977)).

113. The difference between the median values of the average return on equity is so much smaller than the difference between the median values for the average return on total capital because a significant portion of the major airframe builders' total capital is provided by the government and because the major airframe builders tend to have higher debt-equity ratios than firms in other industries. In addition, the difference in Table 5 between median return on total capital for the airframe builders and for all industries probably understates the true difference because 'total capital' in the table excludes human capital, of which the aerospace industry has proportionately more than other industries.

114. More rigorously, a difference of medians test was performed. See W.L. Hays, Statistics (Holt, Rinehart and Winston; New York; 1973), pp. 194-197. Testing the null hypothesis that the average rate of return on equity for the nine major airframe builders has the same distribution as the average rate of return on equity for the other eight aerospace firms included by Forbes (Aerospace and Defense, op.cit., p. 133) against the alternative hypothesis that the other eight firms have a higher median return yielded a critical (at the .05 level) score of six. Since the 'other' sample had only five values above the grand median, the null hypothesis could not be rejected. Since, by inspection, the industry median and the all-industry median are not significantly different, the conclusion stated in the text follows.

115. Several other studies have reached the same conclusion. For example, see Weidenbaum, op.cit., pp. 69-70. It should be emphasized that this conclusion carries no implication regarding the question of whether profits are adequate in relation to risks. Further, it should be noted that if either of the other two measures of profitability in Table 5 are used as the basis of comparison - as they often are in studies sponsored by the aerospace industry - then the opposite conclusion is drawn, namely, that aerospace profits are significantly lower than profits in other industries. See Aerospace Profits vs. Risks, op. cit., pp. 13-17.

116. See Rockwell walks a rough road to profits, op.cit., for a discussion of these acquisitions and the growth motive that lay behind them.

117. This dominance is, of course, one factor that tends to discourage potential entrants.

118. See R.C. Fraser, A.D. Donheiser, and T.G. Miller, Jr., Civil Aviation Development: A Policy and Operations Analysis (Praeger; New York; 1972), pp. 9-12.

119. Both to replace older, less fuel efficient aircraft and to meet new federal noise standards. See Harr, op.cit., p. 14, and Aerospace and Defense, op.cit., p. 136.

120. See Nation's Airlines Face A Key Problem: How To Pay for New Planes, op.cit. The problems, financial and otherwise, that confront the commercial aircraft end of the aerospace industry are discussed in R.C. Fraser, A.D. Donheiser, and T.G. Miller, Jr., op.cit.

121. See The Next Commercial Jet . . . If, op.cit.

122. Harr, op.cit., p. 14. As a result, losses can be large. See Lockheed Sets L-1011 Charge Of $515 Million, op.cit.

123. Harr, op.cit., pp. 14-15. The significance of foreign sales and foreign competition is discussed in the next subsection.

124. Ibid., pp. 15-16.

125. For example, Fairchild Industries is experiencing large losses in trying to start up its communications business and plans to use the profits it hopes to earn on its A-10 contract to pay these start-up costs. See A Last Run For The Money, op.cit. As a second example, Lockheed has experienced large losses on its L-1011 TriStar program, but due to its profitable defense business, is able to meet bond interest payments. "Haack at Lockheed proclaims an upturn," Business Week (June 28, 1976.)

126. This point was made by several of the executives interviewed by the author. Problems these firms face in trying to diversify into commercial markets are discussed in J.S. Gilmore and D.C. Coddington, Defense Industry Diversification (U.S. Arms Control and Disarmament Agency; Washington, D.C.; January 1966).

127. See Rockwell walks a rough road to profits, op.cit., and Rockwell's surprising winner: Collins Radio, op.cit. An earlier study by Gilmore and Coddington reached the opposite conclusion, namely, that aerospace firms favor growth by internal means. Gilmore and Coddington, op.cit. However, their study covered a time period in which the growth prospects in these firms' traditional markets were excellent. Since the managers of these firms were preoccupied with developments in their traditional markets, it is not surprising that Gilmore and Coddington found that the degree of diversification undertaken by these firms was insignificant in terms of its impact on company sales and profits.

128. Aerospace Profits vs. Risks, op.cit., p. 3.

129. During interviews conducted by the author, executives of several of the firms that are more heavily dependent on government sales expressed a desire to see their companies expand their commercial operations enough to attain a 50-50 sales split between government and non-government business. David S. Lewis, Chairman of General Dynamics Corp., has also stated publicly his company's goal of a 50-50 sales split. See "General Dynamics renews its Pentagon romance," Business Week (February 3, 1975).

130. However, as several aerospace executives have recognized, government sales can provide stability when commercial demand weakens - provided the business cycle and the political cycle do not cause military sales and commercial sales to turn down simultaneously. Ibid., pp. 58-59.

131. Harr, op.cit., p. 16.

132. "Anatomy of the Arms Trade," Newsweek (September 6, 1976).

133. See, for example, L. Kraar, "Grumman Still Flies For Navy, But It Is Selling the World," Fortune (February 1976). Over the last decade Northrop Corp.'s major product has been the F-5, the market for which has been almost entirely overseas. See "The New Adventures of Tom Jones," The New York Times (September 19, 1976).

134. See "Belgium Joins Others, Picks U.S.-Built F-16," Wall Street Journal (June 9, 1975); "The Politics Of The F-16," Forbes (December 15, 1976); and "NATO Defense Chiefs Agree in Principle To Buy AWACS if Financing Is Settled," Wall Street Journal (December 9, 1976).

135. Harr, op.cit., p. 16. For a practical example, see "Iran Seeks 300 General Dynamics F-16s, Near Double of What U.S. Agreed to Sell," Wall Street Journal (September 13, 1976).

136. See "Lockheed Signs $1.03 Billion Agreement With Canada for Planes, Related Work," Wall Street Journal (July 22, 1976); Belgium Joins Others, Picks U.S.-Built F-16, op.cit.; and NATO Defense Chiefs Agree in Principle To Buy AWACS if Financing Is Settled, op. cit.

137. See "Buying guns to sell planes," Business Week (June 23, 1975).

138. See "European Members of NATO Strive to Build Weapons Industry to Compete With U.S. Firms," Wall Street Journal (November 3, 1976).

139. Harr, op.cit., p. 15. The foreign-owned airlines have also contributed greatly to overcapacity on international routes, and, to the extent that such overcapacity has hurt the U.S. international airlines financially, this may have had a detrimental impact on commercial aircraft sales of the U.S. aerospace industry. See T. O'Hanlon, "The Mess That Made Beggars of Pan Am and T.W.A.," Fortune (October 1974).

140. See "Air Transportation: The Real Issues," Government Executive (October 1976), for a discussion of the consequences of this pooling.

141. Harr, op.cit., p. 15.

142. See Free-world partners plan jets for the 1980s, op.cit.

143. These longer periods are, in one case, a short term planning period of five years and a long term planning period of ten years, and in the other case, a short term planning period of two years and a long term planning period of seven years. The other seven firms use the one year and five year time horizons stated in the text.

144. In many cases there is more than one division, as for example, McDonnell Aircraft Company, which produces mainly military aircraft, and Douglas Aircraft Company, which produces mainly commercial aircraft (and which was a separate company until taken over by McDonnell in 1965) of McDonnell Douglas Corp.

145. In several cases, such as LTV's Vought Corp., the aerospace operations are centralized in a wholly owned subsidiary, rather than a division, and the parent company is a holding company. For the purposes of this paper, the distinction between a division and a wholly owned subsidiary is not an important one since it does not affect the corporate planning process.

146. These are discussed in J.D. Finnerty, "Models of the Firm: A Survey of the Literature," unpublished paper (Naval Postgraduate School; Monterey, CA; February 1977), ch. 2.

147. Ibid., ch. 2 (and in particular, section G).

148. Ibid., ch. 2 (and in particular, section H).

149. For the eight of the nine firms that have a company president - General Dynamics has instead three executive vice presidents with specific area responsibilities within which each serves in the same capacity as the president of a subsidiary would (see General Dynamics: Winning in the Aerospace Game, op.cit.) - that individual (and often one or more other top executives) sits on the board of directors.

150. Major shareholders are particularly influential at McDonnell Douglas and Rockwell, where they hold top management positions, including chairman of the board of directors, and at General Dynamics, where the major shareholder personally recruited the chairman of the board of directors. See Rockwell walks a rough road to profits, op.cit., which describes Chairman Willard F. Rockwell's role in determining Rockwell International's objectives, and General Dynamics: Winning in the Aerospace Game, op.cit., which describes the influence of the firm's largest stockholder, Henry Crown.

151. To make the author's view of the typical airframe builder's objectives more clear, it is his belief that each of the three theories - traditional, managerial, and behavorial - has something to contribute to the overall understanding of these firms' objectives, though any one of the three on its own gives an incomplete picture.

152. General Dynamics renews its Pentagon romance, op.cit.

153. The question of weapons system quality and the preferences of the U.S. government with regard to quality, cost, and development time are discussed in Peck and Scherer, op.cit., ch. 10.

154. This carryover effect is probably stronger the greater is the technological complementarity between the particular commercial product and the firm's high technology military aircraft, e.g. it is likely to be stronger for commercial aircraft than for such items as refrigerators or canoes.

155. The connection between proposed projects and managerial emoluments may appear somewhat tenuous. In many cases, however, a portion of managerial compensation is based on an incentive compensation scheme, so that proposed projects can affect compensation through their impact on the company's performance, For example, Boeing has an incentive compensation plan. See The Boeing Company Form 10-K, op. cit., p. 14 and Exhibit 15.

156. For eight of the nine firms - Rockwell, whose fiscal year ends September 30, is the exception - the fiscal year parallels the calendar year. Unfortunately, the one exception makes it necessary to describe the planning cycle in terms of quarters (of the fiscal year), rather than in terms of calendar months.

157. For example, if the objective is held to be expected utility maximization, then specifying the appropriate utility function involves theoretical, as well as practical, difficulties. See G.M. Heal, The Theory of Economic Planning (American Elsevier; New York; 1973), ch. 2.

158. For example, formulating the planning problem as a nonlinear programming problem that contained an objective function that reflected not only the objectives discussed in section C, but also the existence of uncertainty, and that also contained the many constraints needed to characterize the real-world planning problem, might lead to any one, or possibly several, of the problems often encountered in trying to solve large scale nonlinear programming problems. See H.M. Wagner, Principles of Operations Research, 2nd ed. (Prentice-Hall; Englewood Cliffs, N.J.; 1975), chs. 14-15.

159. A third reason could be added to the two already mentioned: a basic distrust of planning models. Several of the planning executives interviewed by the author were steadfast in their belief that planning models of any kind - whether of the mathematical programming variety, of the simulation variety, or of some other variety - would disrupt, rather than promote, the long term and short term planning process.

160. The notion of a planning process that is optimal in the sense of being most cost effective, rather than in the sense of leading to an optimal solution to the planning problem, is analogous to Baumol's and Quandt's optimally imperfect

rules of thumb for business decisions. See W.J. Baumol and R.E. Quandt, "Rules of Thumb and Optimally Imperfect Decisions," American Economic Review (vol. 54; no. 2; March 1964), pp. 23-46.

161. The terms 'division' and 'divisional', it should be re-emphasized, are used to refer to the principal operating units of the corporation. These principal operating units are variously referred to as companies (e.g. Douglas Aircraft Company and McDonnell Aircraft Company of McDonnell Douglas Corp.), as divisions (e.g. Convair Division and Fort Worth Division of General Dynamics Corp.), as subsidiaires (e.g. Vought Corp of LTV Corp. and Grumman Aerospace Corp. of Grumman Corp.), and as groups (e.g. Admiral Group of Rockwell International Corp.). Often the principal operating units will themselves have divisions, but in what follows the focus is on the principal operating units, and the terms 'division' and 'divisional' refer to these units only and not to their subdivisions.

162. See the previous footnote.

163. Note that the three plans outline the division's needs for three classes of resources. The technical plan deals with human capital resources; the manpower and production plan deals essentially with labor resources (although managerial talent also contains a large human capital component); and the facilities plan deals with physical capital resources.

164. See footnotes 3 and 94.

165. It is almost universially accepted within the industry that once a new weapons program appears in the Five Year Defense Plan it is generally too late to begin the research and development process for that program.

166. Also, as will be pointed out in the next section, it is the division's responsibility, in formualting the operating plan, to allocate sufficient manpower and funds to form the required bid and proposal teams for those new programs on which the company (through the division) intends to bid.

167. Early Revival Unlikely As Jumbo-Plane Sales Continue to Languish, op.cit.

168. Boeing, McDonnell Douglas, and Lockheed are doing this, but Boeing's 747 production line and McDonnell Douglas's DC-10 production line were each operating at approximately 20% of capacity at the end of 1976. Ibid.

169. See "Swissair Seeks to Launch New DC9 Model With Order to McDonnell Douglas Corp.," Wall Street Journal (January 20, 1977).

170. For example, an airplane that costs $30 million to build will involve an interest cost of $250,000 for every month it remains unsold (assuming an annual interest rate of 10 percent.)

171. See, for example, Lockheed Sets L-1011 Charge Of $515 Million, op.cit.

172. See, for example, T.W. Schultz, Investment in Human Capital (Free Press; New York; 1971); R.A. Wykstra, ed., Human Capital Formation and Manpower Development (Free Press; New York; 1971); B.F. Kiker, ed., Investment in Human Capital (University of South Carolina Press; Columbia, S.C.; 1971); F. Welch, "Education in Production," Journal of Political Economy (vol. 78; no. 1; January-February 1970), pp. 35-59; and G.S. Becker, Human Capital, 2nd ed. (Columbia University Press; New York; 1975).

173. Schultz, op.cit., ch. 3.; B.F. Kiker, "The Historical Roots of the Concept of Human Capital," in Kiker, op.cit., pp. 51-77; and Becker, op.cit., ch. II. A broader definition of human capital would also include the skills and know-how embodied in the firm's production workers, but since the focal point of this section is long term planning, and in particular, the allocation of scientists, engineers, designers, and technicians, the narrower definition provided in the text seems to this writer more appropriate.

174. The distinction between fixed capital and human capital, as well as the distinction between these types of capital and other types of capital, are discussed in the papers cited in footnote 172.

175. Under the wider definition of human capital, which was mentioned in footnote 173, one would have to include also the services of human capital (embodied in production workers) that are provided during the production phase of the program. This particular flow of human capital services underlies the learning curve discussed in section B.

176. This is particularly important in the airframe industry, where, as discussed in section B, a significant portion of the total fixed capital is provided by the government.

177. One of the consequences of the human capital embodied in aerospace engineers and scientists may be the existence of a segmented labor market for persons embodying these skills and knowledge. This body of theory is discussed in G.G. Cain, "The Challenge of Segmented Labor Market Theories to Orthodox Theory: A Survey," Journal of Economic Literature (vol.14; no. 4; December 1976), pp. 1215-1257.

178. The difficulties and costs associated with trying to evaluate a prospective employee's stock of human capital are discussed in J.G. Riley, "Information, Screening and Human Capital," American Economic Review (vol. 66; no. 2; May 1976), pp. 254-260.

179. And this is likely to become increasingly important as the Department of Defense implements its new design-to-cost policy. The policy is outlined in several DOD and service instructions beginning with Department of Defense Directive 5000.28, "Design to Cost" (May 23, 1975). The concept of design to cost is explained in J.J. Bennett, "Design to Cost", Commander's Digest (vol. 19; no. 17; August 12, 1976).

180. These firms' reluctance to lay off key engineering personnel, for example, has led to accusations of hoarding of engineering personnel. Several studies have provided evidence that engineering talent is being wasted in jobs that require only routine skills. See Peck and Scherer, op.cit., pp. 515-517. This supposed 'hoarding' may, in the opinion of this writer, still be less costly to the firm than a policy of hiring and firing due to the potentially high costs of searching for the required talent.

181. Harr, op.cit., p. 12.

182. The two exceptions are noted in footnote 143. In each of these cases, however, the first year's operating plan is given in the greatest detail and is presented in the form of a budget.

183. The budget preparation process is described in management accounting textbooks. See, for example, R.N. Anthony and G.A. Welsch, Fundamentals of Management Accounting (Irwin; Homewood, Ill; 1974), ch. 11.

184. In some cases, however, the projections for the first few years of the long term plan are broken out on a quarter-by-quarter basis.

185. The overhead rate is a ratio that is applied to the cost of an hour of direct labor in order to allocate indirect costs, such as general and administrative expenses, depreciation and maintenance, utilities, etc., over the goods produced. Often several different overhead rates are used. For example, government procurement regulations favor the following three: a manufacturing overhead rate, an engineering overhead rate, and a general and administrative expenses overhead rate. See Defense Procurement

Circular No. 76-3, op.cit., p. 11. A general discussion of overhead rates and their computation can be found in Anthony and Welsch, op.cit., pp. 70-74. Using their terminology, the contractor and the government negotiate a 'predetermined overhead rate' for each overhead cost pool once a year. The evaluation of overheads as part of determining contractor fees is discussed in Defense Procurement Circular No. 76-3, op.cit., pp. 11-12. The apparent tendency for contractors to try to include indirect labor as direct labor in order to reduce the overhead rates and appear more efficient than they really are is argued in Peck and Scherer, op.cit., pp. 517-519.

186. This is not meant to suggest that such 'assistance' is always welcomed by the contractor.

187. Recently, as one result of the Profit '76 study, the weight attached to contractor performance in determining the fee to be earned on a contract has been reduced from 65% to 50%. See Defense Procurement Circular No. 76-3, op.cit., p. 2.

188. Ibid., pp. i-ii.

189. Due to the importance of meeting delivery schedules, there may be a tendency for firms to overman. See Peck and Scherer, op.cit., pp. 516-517. Such overmanning, to the extent that it reduces the risk of late delivery (and poor contract performance) and to the extent that the cost of overmanning is borne by the government, constitutes a transfer of risk from the contractor to the government.

190. See Early Revival Unlikely As Jumbo-Plane Sales Continue to Languish, op.cit.

191. Several executives interviewed by the author indicated that, even when commercial demand is strong, these advance payments seldom exceed 25% of production costs, as opposed to the government's provision of progress payments covering 80% of (allowable) costs.

192. Ibid.

193. This is not meant to imply that divisional managers always wait until the corporate review to indicate problem areas, although this may happen. Normally, serious problems are called to the attention of top management as they arise, and the corporate review process is one place where top management can become forewarned of potential problem areas.

REFERENCES

Aerospace Industries Association of America, Aerospace Profits vs. Risks (Washington, D.C.; June 1977).

———, Monopsony: A Fundamental Problem in Government Procurement (Washington, D.C.; May 1973).

———, *Risk Elements in Government Contracting* (Washington, D.C.; October 1970).

A.M. Agapos and L.E. Gallaway, "Defense Profits and the Renegotiation Board in the Aerospace Industry," Journal of Political Economy (vol. 78; no. 5; September/October 1970), pp. 1093-1105.

R.N. Anthony and G.A. Welsch, Fundamentals of Management Accounting (Irwin; Homewood, Ill.; 1974).

K.J. Arrow, "The Economic Implications of Learning by Doing," Review of Economic Studies (vol. 29; 1962), pp. 155-173.

H. Asher, "Cost-Quantity Relationships in the Airframe Industry," R-291 (The RAND Corporation; Santa Monica, CA; 1956).

Aviation Week & Space Technology, various issues.

D.P. Baron, "Incentive Contracts and Competitive Bidding," American Economic Review (vol. 62; no. 3; June 1972), pp. 384-394.

———, "Incentive Contracts and Competitive Bidding: Reply," American Economic Review (vol. 64; no. 6; December 1974), pp. 1072-1073.

W.J. Baumol and R.E. Quandt, "Rules of Thumb and Optimally Imperfect *Decisions*," *American Economic Review* (vol. 54; no. 2; March 1964), pp. 23-46.

G.S. Becker, Human Capital, 2nd ed. (Columbia University Press; New York; 1975).

J.J. Bennett, "Design to Cost," Commander's Digest (August 12, 1976).

C.C. Blaydon and P.W. Marshall, "Incentive Contracts and Competitive Bidding: Comment", American Economic Review (vol. 64; no. 6; December 1974), pp. 1070-1071.

The Boeing Company SEC Form 10-K, annual report for company fiscal year 1975.

J.K. Brown and G.S. Stothoff, The Defense Industry: Some Perspectives from the Financial Community (Division of Management Research, The Conference Board; New York; 1976).

Business Week, various issues.

G.G. Cain, "The Challenge of Segmented Labor Market Theories to Orthodox Theory: A Survey," Journal of Economic Literature (vol. 14; no. 4; December 1976), pp. 1215-1257.

M.E. Canes, "The Simple Economics of Incentive Contracting: Note," American Economic Review (vol. 65; no. 3; June 1975), pp. 478-483.

S.L. Carroll, "The Airframe Industry," unpublished Ph.D. dissertation (Harvard University; Cambridge, Mass.; August 1970).

Department of Defense, Defense Procurement Circular Number 76-3 (Washington, D.C.; September 1, 1976).

Department of Defense Directive 5000.1, "Major System Acquisitions" (January 18, 1977).

Department of Defense Directive 5000.2, "Major System Acquisition Process" (January 18, 1977).

Department of Defense Directive 5000.28, "Design to Cost" (May 23, 1975).

Dun and Bradstreet, Inc., Dun and Bradstreet Million Dollar Directory (New York, N.Y.; 1975).

The Economist, various issues.

S. Enke, ed., Defense Management (Prentice-Hall; Englewood Cliffs, N.J.; 1967).

S.J. Evans, H.J. Margulis, and H.B. Yoshpe, Procurement (Industrial College of the Armed Forces; Washington, D.C.; 1968).

Fairchild Industries, Inc., 1975 Annual Report (Fairchild Industries, Inc., Germantown, Md.).

Fairchild Industries, Inc., SEC Form 10-K, annual report for company fiscal year 1975.

J.D. Finnerty, "Models of the Firm: A Survey of the Literature ," unpublished paper (Naval Postgraduate School; Monterey, CA.; February 1977).

Forbes, various issues.

"The Fortune Directory of the 500 Largest Industrial Corporations," Fortune (May 1971).

"The Fortune Directory of the 500 Largest Industrial Corporations," Fortune (May 1976).

"The Fortune Directory of the Second 500 Largest Industrial Corporations," Fortune (June 1976).

J.R. Fox, Arming America: How the U.S. Buys Weapons (Division of Research, Harvard Business School; Boston; 1974).

R.C. Fraser, A.D. Donheiser, and T.G. Miller, Jr., Civil Aviation Development: A Policy and Operations Analysis (Praeger; New York; 1972).

General Dynamics Corporation SEC Form 10-K, annual report for company fiscal year 1975.

J.S. Gilmore and D.C. Coddington, Defense Industry Diversification (U.S. Arms Control and Disarmament Agency; Washington, D.C.; January 1966).

J.F. Gorgol, The Military-Industrial Firm (Praeger; New York; 1972).

Government Executive, October 1976 issue.

Grumman Corporation SEC Form 10-K, annual report for company fiscal year 1975.

K.G. Harr, Jr., "A Short Course in Aerospace Economics 1976," Aerospace (September 1976), pp. 6-16.

K. Hartley, "The Learning Curve and Its Application to the Aircraft Industry," Journal of Industrial Economics (vol. 13; no. 2; March 1965), pp. 122-128.

W.L. Hays, Statistics (Holt, Rinehart and Winston; New York; 1973).

G.M. Heal, The Theory of Economic Planning (American Elsevier; New York; 1973).

W.Z. Hirsch, "Firm Progress Ratios," Econometrica (vol. 24; no. 2; April 1956), pp. 136-143.

J. Hirshleifer, Investment, Interest, and Capital (Prentice-Hall; Englewood Cliffs, N.J.; 1970).

A. Kanter and S.J. Thorson, "The Weapons Procurement Process: Choosing Among Competing Theories," in S. Rosen, ed., Testing the Theory of the Military Industrial Complex.

C. Kaysen, "Improving the Efficiency of Military Research and and Development," in E. Mansfield, ed., Defense, Science, and Public Policy.

B.F. Kiker, "The Historical Roots of the Concept of Human Capital," in B.F. Kiker, ed., Investment in Human Capital.

———, ed., Investment in Human Capital (University of South Carolina Press; Columbia, S.C.; 1971).

F.H. Knight, Risk, Uncertainty, and Profit (Houghton Mifflin; New York; 1921).

L. Kraar, "Grumman Still Flies For Navy, But It Is Selling the World," Fortune (February 1976).

J.R. Kurth, "Aerospace Production Lines and American Defense Spending," in S. Rosen, ed., Testing the Theory of the Military-Industrial Complex.

———, "Why We Buy The Weapons We Do," Foreign Policy, (Number 11; Summer 1973), pp. 33-56.

The LTV Corporation SEC Form 10-K, annual report for company fiscal year 1975.

Lockheed Aircraft Corporation SEC Form 10-K, annual report for company fiscal year 1975.

E. Mansfield, ed., Defense, Science, and Public Policy (W.W. Norton; New York; 1968).

J.J. McCall, "The Simple Economics of Incentive Contracting," American Economic Review (vol. 60; no. 5; December 1970), pp. 837-846.

McDonnell Douglas Corporation SEC Form 10-K, annual report for company fiscal year 1975.

R.N. McKean, ed., Issues in Defense Economics (Columbia University Press; New York; 1967).

F.T. Moore, "Incentive Contracts", in S. Enke, ed., Defense Management.

"The New Adventures of Tom Jones," New York Times (September 19, 1976).

Newsweek, September 6, 1976 issue.

Northrop Corporation SEC Form 10-K, annual report for company fiscal year 1975.

T. O'Hanlon, "The Mess That Made Beggers of Pan Am and T.W.A," Fortune (October 1974).

M.J. Peck and F.M. Scherer, The Weapons Acquisition Process: An Economic Analysis (Division of Research, Harvard Business School; Boston; 1962).

G.C. Philippatos, Financial Management Theory and Techniques (Holden-Day; San Francisco; 1971).

Profit '76 Summary Report (U.S. Government Printing Office; Washington, D.C.; December 7, 1976).

W.C. Ridder and M.K. Heinz, "Structure, Conduct, and Performance of the United States Aerospace Industry," unpublished M.S. thesis (Naval Postgraduate School; Monterey, CA.; March 1976).

J.G. Riley, "Information, Screening and Human Capital," American Economic Review (vol. 66; no. 2; May 1976), pp. 254-260.

Rockwell International Corporation SEC Form 10-K, annual report for company fiscal year 1975.

S.J. Rosen, ed., Testing the Theory of the Military-Industrial Complex (D.C. Heath; Boston; 1973).

N. Rosenberg, "On technological expectations," Economic Journal (vol. 86; no. 343; September 1976), pp. 523-535.

F.M. Scherer, "The Theory of Contractual Incentives for Cost Reduction," Quarterly Journal of Economics (vol. 78; no. 2; May 1964), pp. 257-280.

————, The Weapons Acquisition Process: Economic Incentives (Division of Research, Harvard Business School; Boston; 1964).

T.W. Schultz, Investment in Human Capital (Free Press; New York; 1971).

R. Sherman, The Economics of Industry (Little, Brown and Company; Boston; 1974).

Standard and Poor's Corp., Standard and Poor's Register of Corporations, Directors, and Executives, vol. 3 (New York, N.Y.; January 1975).

Stanford Research Institute, "The Industry-Government Aerospace Relationship," two volumes (Menlo Park, CA.; May 1963).

H.O. Stekler, The Structure and Performance of the Aerospace Industry (University of California Press; Berkley; 1965).

J.M. Suarez, "Profits and Performance of Aerospace Defense Contractors," Journal of Economic Issues (vol. 10; no. 2; June 1976), pp. 386-402.

J.C. Van Horne, Financial Management and Policy, 2nd ed. (Prentice-Hall; Englewood Cliffs, N.J.; 1971).

P.J. Verdoorn, "Complementarity and Long-Range Projections," Econometrica (vol. 24; no. 4; October 1956) , pp. 429-450.

D. Vickers, The Theory of the Firm: Production, Capital, and Finance (McGraw-Hill; New York; 1968).

H.M. Wagner, Principles of Operations Research, 2nd ed. (Prentice-Hall; Englewood Cliffs, N.J.; 1975).

The Wall Street Journal, various issues.

S.C. Webb, Managerial Economics (Houghton Mifflin; Boston; 1976).

M.L. Weidenbaum, The Economics of Peacetime Defense (Praeger; New York; 1974).

F. Welch, "Education in Production," Journal of Political Economy (vol. 78; no. 1; January-February 1970), pp. 35-59.

J.F. Weston, ed., Procurement and Profit Renegotiation (Wadsworth; San Francisco; 1966).

O.E. Williamson, "The Economics of Defense Contracting: Incentives and Performance," in R.N. McKean, ed., Issues in Defense Economics.

T.P. Wright, "Factors Affecting the Cost of Airplanes," Journal of the Aeronautical Sciences (vol. 3; no. 4; February 1936), pp. 122-128.

R.A. Wykstra, ed., Human Capital Formation and Manpower Development (Free Press; New York; 1971).

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